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INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

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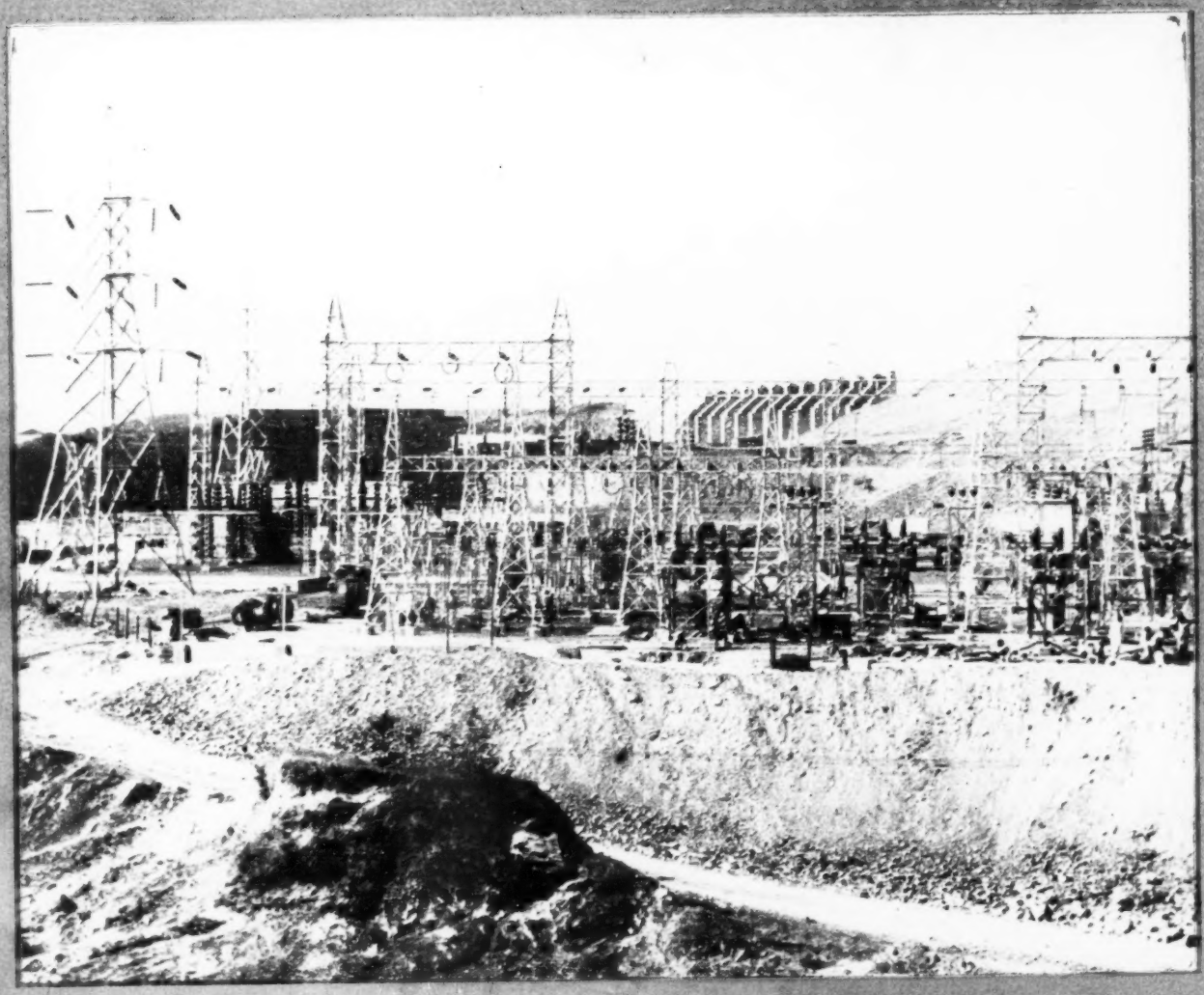

OUTDOOR SWITCHYARD AT THE MAITHON DAM AND POWER HOUSE

ING EARTH

FOR PROSPERITY

'INTERNATIONAL' TD-24'S DUTY AT CHAMBAL

In Madhya Pradesh and Rajasthan men and machines work day and night to harness the wayward Chambal for irrigating arid lands and generating cheap hydro-electric power for industrial progress.

A very important role in this 'mighty adventure' is being played by over 50 International TD-24 Crawler Tractors which are fitted with a variety of suitable equipment to grapple with the toughest earthmoving jobs.

On this, as on other river-valley projects in India, the TD-24 is doing a magnificent job, tackling the toughest earthmoving assignments with the characteristic 'International' ease, efficiency and economy.

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WORLD'S MOST ECONOMICAL DIESEL CRAWLER TRACTOR

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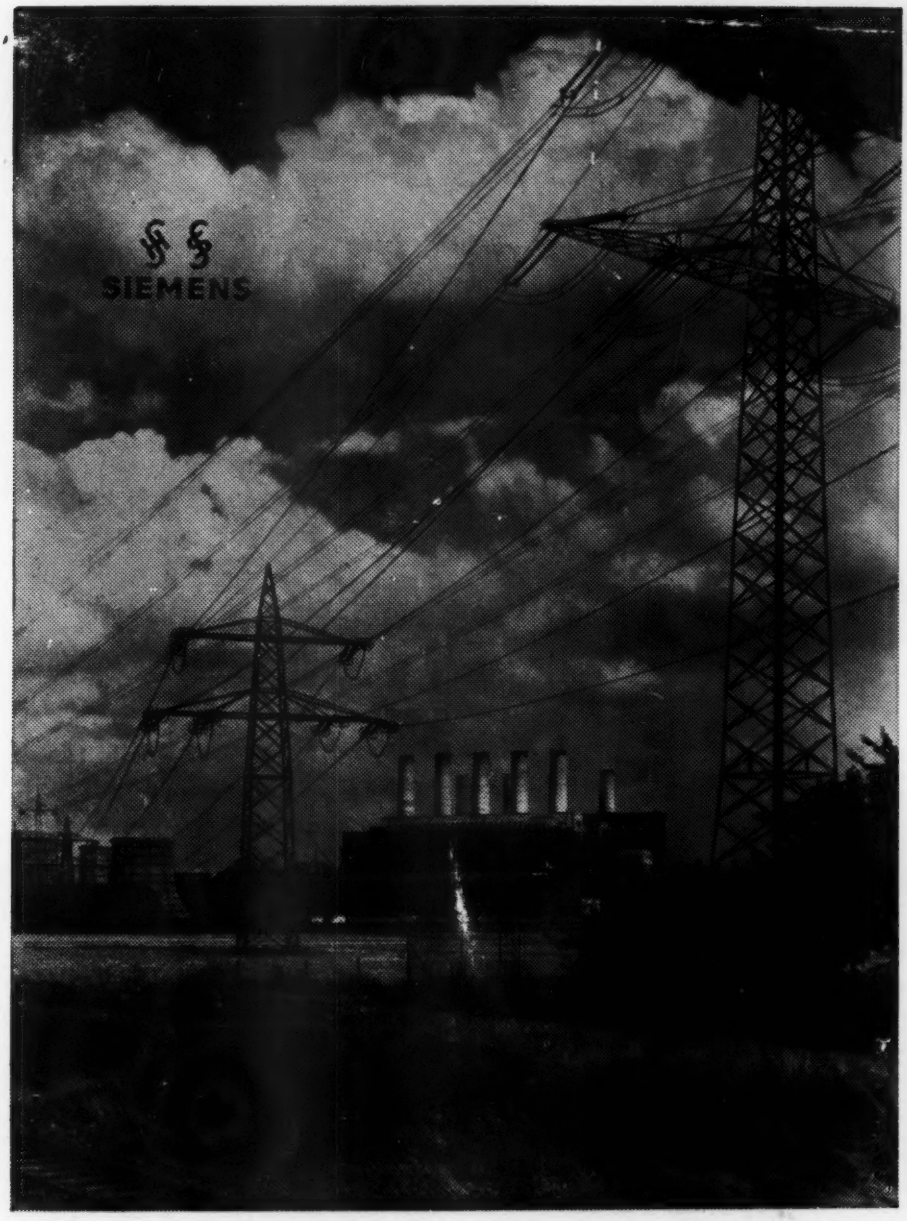

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SOLE REPRESENTATIVES :

SIEMENS ENGINEERING & MANUFACTURING CO. OF INDIA PRIVATE LTD.

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Cement builds his home. It is in the pavement on which he walks, the school in which he learns the arts of man, the hospital which he may need, the swimming pool, sports track and gymnasium that build his team spirit and his muscle. It is in the dams, power houses, factories, grain silos . . .

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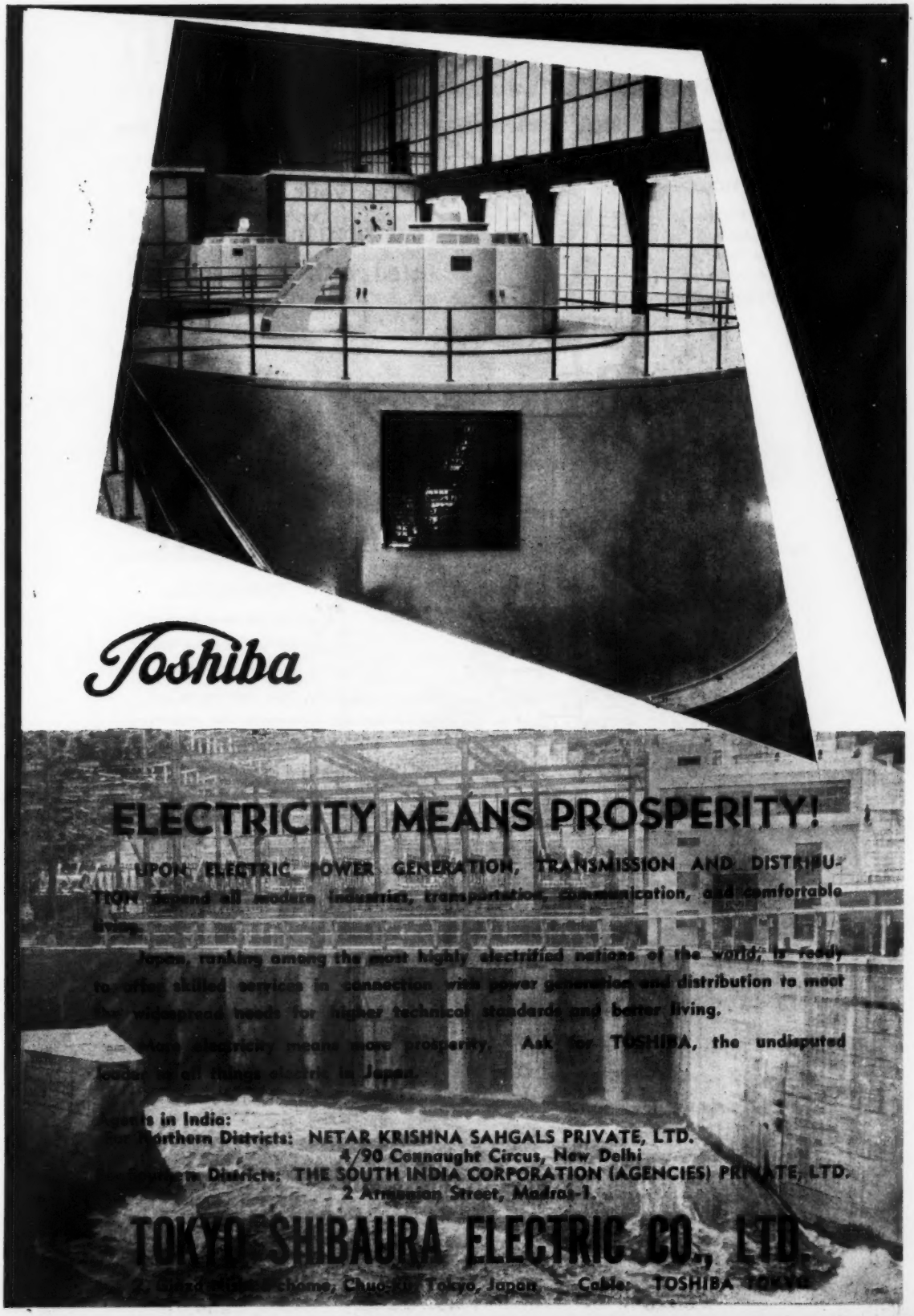
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UPON ELECTRIC POWER GENERATION, TRANSMISSION AND DISTRIBUTION depend all modern industries, transportation, communication, and comfortable living.
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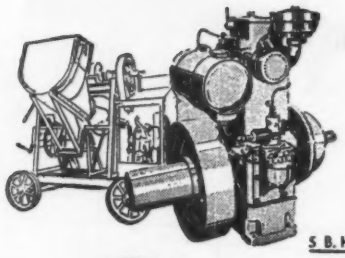

5 B.H.P.

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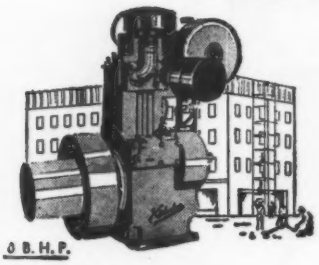
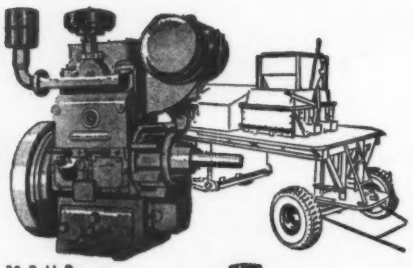
Construction Machinery
fitted with



6 B.H.P.

Kirloskar

DIESEL ENGINES



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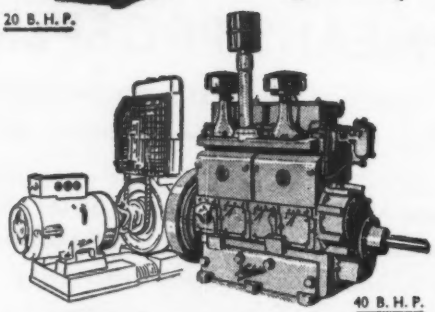
KIRLOSKAR diesel engines are used for all industrial and engineering purposes. Outstanding reliability, rigid construction and efficient performance—the outcome of years of experience in sound design and workmanship—make Kirloskar diesel engines popular in the field of constructive engineering. These engines are designed in such a way that they can be handled easily even by unskilled labour.



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KIRLOSKAR OIL ENGINES LTD., KIRKEE, POONA 3

ROEL 6-1 56

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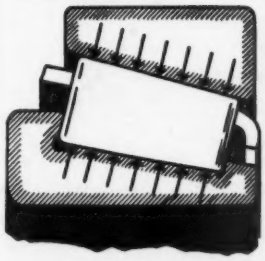
TAPERED ROLLER BEARINGS ***can solve these problems on the machines and equipment you build or buy***

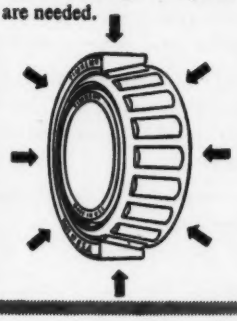
HEAVY LOADS

Loads carried on the rollers and races of Timken bearings are spread evenly over a full line of contact. This greater load area assures extra load-carrying capacity.



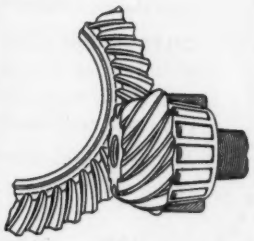
COMBINATION LOADS

Due to their tapered design, Timken bearings carry radial and thrust loads in *any* combination. No auxiliary thrust bearings or plates are needed.



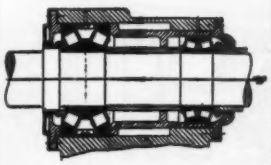
PRECISION

Timken bearings hold shafts in positive alignment, prevent end-movement, minimize deflection. Gears mesh precisely, assuring a smooth flow of power.



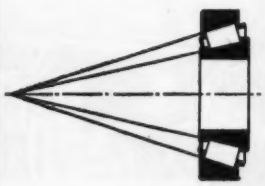
MAINTENANCE

Closures are more effective because Timken bearings keep housing and shaft concentric. Dirt and grit are kept out. Lubricant is kept in.



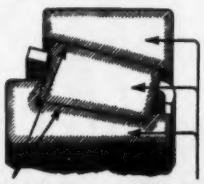
FRICTION

Timken bearings roll freely due to true rolling motion. Lines coincident with the tapered surfaces of rollers and races meet at a common point on the bearing's axis.



WEAR

Rollers and races of Timken bearings are made of Timken fine alloy steel—case-hardened for a hard, wear-resistant surface and a tough shock-resisting core.



CASE-CARBURIZED WEAR-RESISTANT SURFACE — TOUGH, SHOCK-RESISTING CORE

Be sure to specify TIMKEN (made in U.S.A.) Tapered Roller Bearings

World-Wide Availability

TIMKEN Made in U.S.A.

TRADE-MARK OWNED AND REGISTERED BY THE TIMKEN ROLLER BEARING COMPANY

TAPERED ROLLER BEARINGS

THE TIMKEN ROLLER BEARING COMPANY,
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Also makers of fine alloy steel, removable rock bits.

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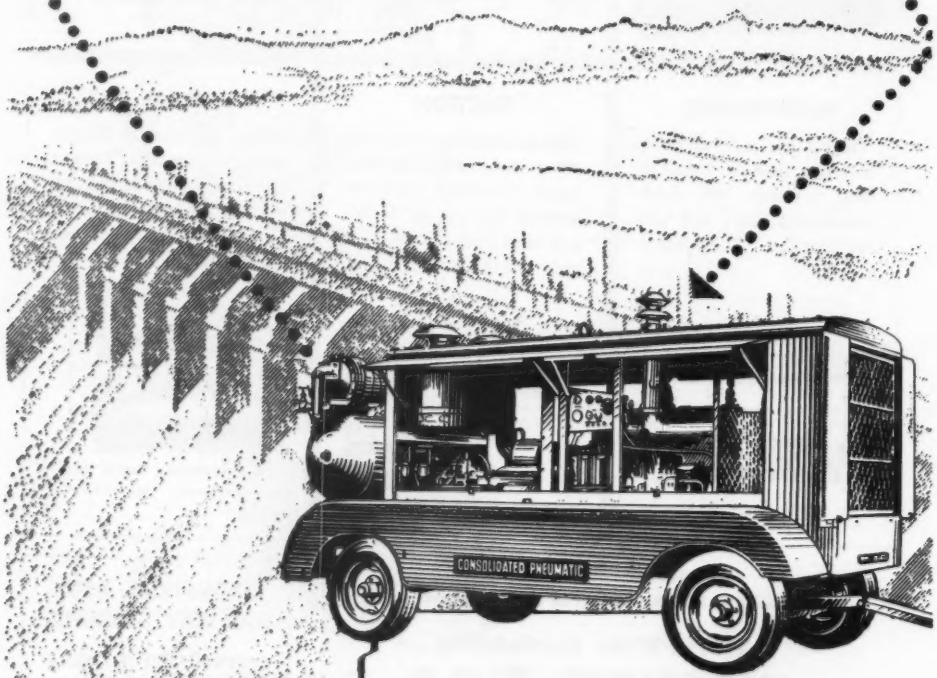
CP AIR COMPRESSOR

Powered by a ***ROLLS-ROYCE ENGINE*** *— the world's best*

Power Vane Compressors are the latest in Compressed Air Equipment. **No Crankshaft. No Valves. No Clutches.** And yet the output is 40/50% more than the reciprocating type for plant of the same size.

OILFLOODED—The cooling of compressed air is by a mist of lubricating oil sprayed along with inlet air. The discharged temperatures are nearly 100° to 150° Flower than the two-stage reciprocating machines.

And yet consumption of lubricating oil is lower than that required for reciprocating machines.



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TOOL COMPANY LIMITED

(Makers of Highclass Rock Drills, Air Compressors and Power Tools.)
Post Box 205, Bombay-1. Phone: 242447.

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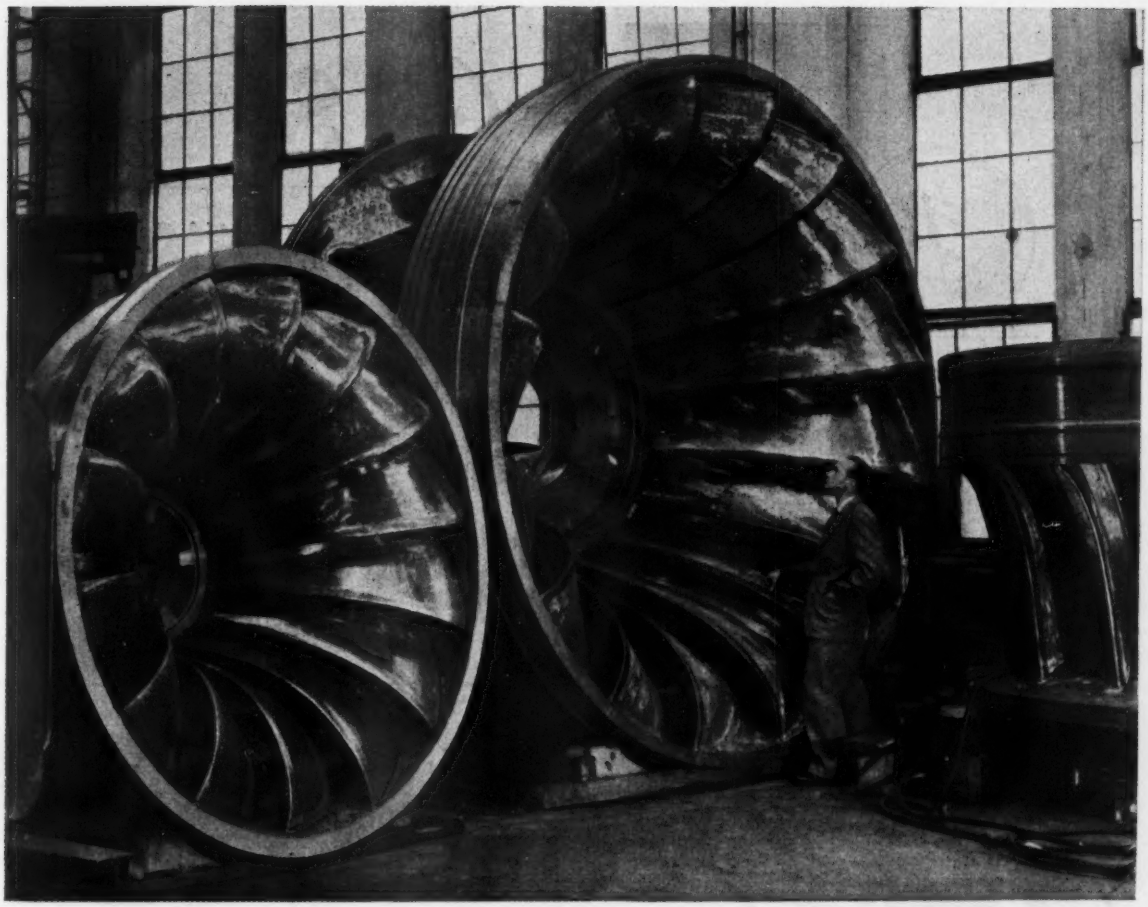

Runners for Francis turbines in our works. The runner to the left is installed in Laforsen Power Station and the one in the centre in Storfinnforsen Power Station. These two Power Stations were described in the No. 6/1956 of this journal.

NOHAB IS MANUFACTURING THE MOST POWERFUL TURBINES IN THE WORLD.

These turbines will be delivered to the power plant at Stornorrfors in North Sweden. Max. guaranteed output 200,000 h.p. per turbine.

BIG KAPLAN-TURBINE FOR INDIA— In the later part of 1955 we received an order from Damodar Valley Corporation for a turbine to the Panchet Hill Hydro-Electric Power Plant and this is said to be the largest Kaplan-turbine in India with regard to output as well as dimensions. Max. output 81,000 h.p. Diameter of the runner 17 ft. 8 in. Panchet Hill is situated on the Damodar river, 150 miles west of Calcutta.

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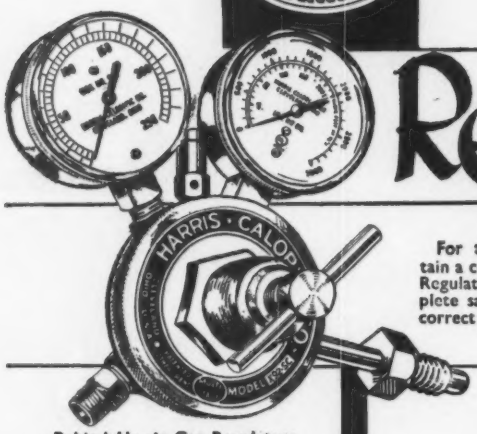

For accurate and uniform regulation of gas to maintain a correct flame, there is none better than a Harris Regulator. The design and construction ensure complete safety, long life, positive and sensitive control and correct reading of gas pressure and contents.

Behind Harris Gas Regulators lie 50 years' specialisation and manufacturing experience.

THE ASIATIC OXYGEN AND ACETYLENE CO., LTD.
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CONCRETE MIXERS

"NON-TILT"
Loader-Fed type

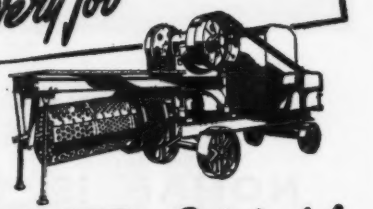
Synchronized loading, mixing and discharging: Fast double-mixing action and speedy discharge. Capacity 10/7 or 14/10 cubic feet.

"SPEEDIA"
Tilting-Drum type

Quick-mix blades; sealed roller bearings; geared tilting; roller chain drive. Capacity 7/5 or 10/7 cubic feet.

For particulars apply to:

Take better crushing to every job



PARKER Portable CRUSHING OUTFIT

You won't beat Parker Outfits either for crushing ability, or portability. Whenever there is a need for a crushing plant that you can move about freely and which will prove dependable at all times . . . . the PARKER range will almost certainly offer the perfect choice. A very wide range of crushers and capacities are available. Full details will be sent upon application.

HEATLY & GRESHAM
ESTABLISHED 1892 LIMITED INCORPORATED IN ENGLAND

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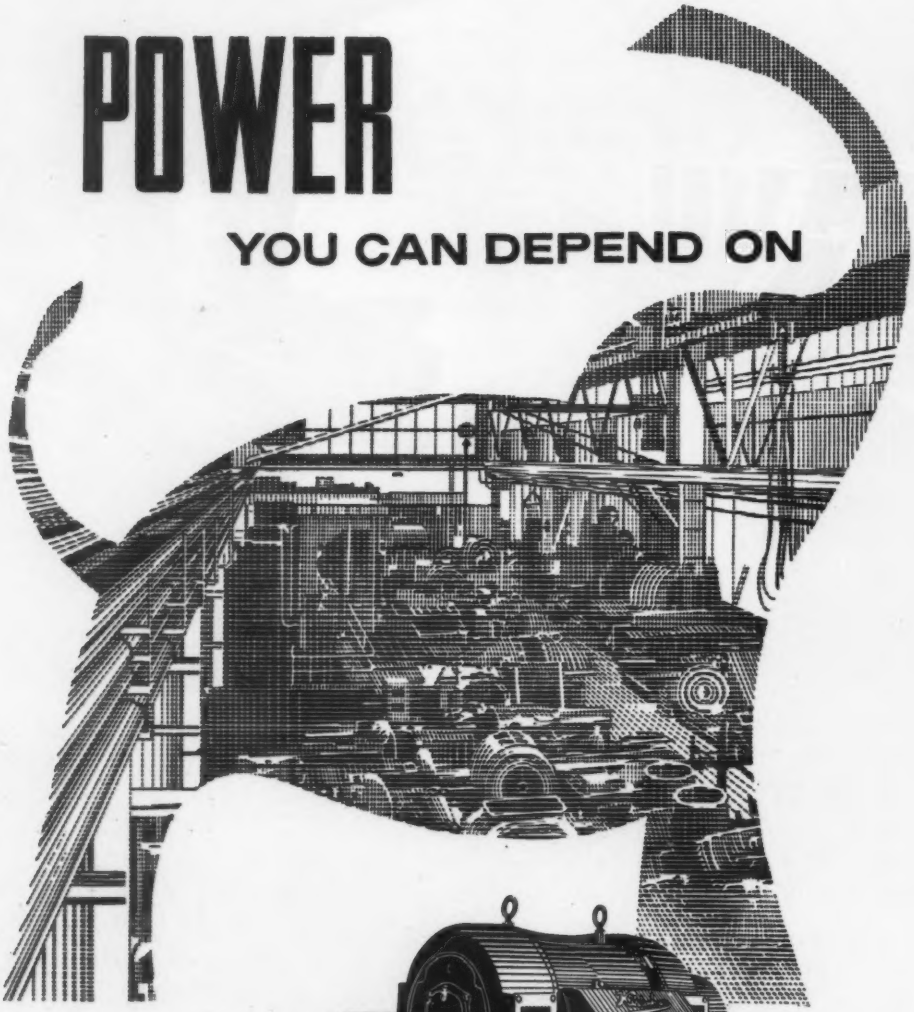
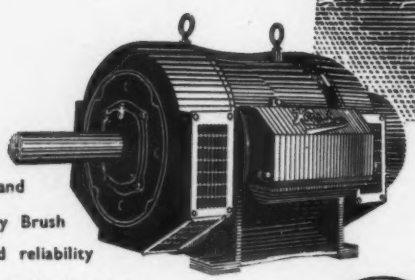
TECHNOEXPORT

POWER

YOU CAN DEPEND ON





Continued leadership in design, improved methods of manufacture, and rigid inspection, guarantee to every Brush Kirloskar Electric Motor a strength and reliability which ensure dependable power and long, trouble-free service.

KIRLOSKAR ELECTRIC CO., LTD. BANGALORE-3.

SOLE AGENTS: PARRY & CO. LIMITED POST BOX No. 12, DARE HOUSE, MADRAS.

EXTRA USES EXTRA PROFITS

with 8 NEW TRAXCAVATOR ATTACHMENTS

For many years, thousands of users have known the TRAXCAVATOR as an excavating tool. Now, it is a *many-purpose machine* . . . with this latest announcement by your Caterpillar Dealer.

For here are eight new, soundly engineered attachments, matched to the three models in the Caterpillar-built Traxcavator line. Each can make you money on its particular application. All of them together put the Traxcavator far ahead in versatility and job usefulness. Now, more than ever before, plan more uses, more bids, more jobs with a Traxcavator.

Turn the page for more facts. Then make a date with your Caterpillar Dealer for the full story about these eight new "money-makers!"

EXTRA Jobs you can handle . . . at lower cost with NEW TRAXCAVATOR TOOLS

- *Load and carry broken pavement.*
- *Dig and load hard-packed clay.*
- *Carry pipe, lumber, forms, pallets.*
- *Excavate hard or frozen ground.*
- *Bulldoze with straight or angle 'dozer.*
- *Load heavy rock—sift fines.*
- *Backfill trenches, ditches.*
- *Handle maximum loads of light materials.*

. . . plus many, many more!

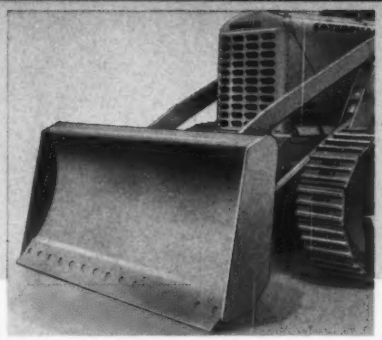
YOUR CATERPILLAR DEALER

EXTRA

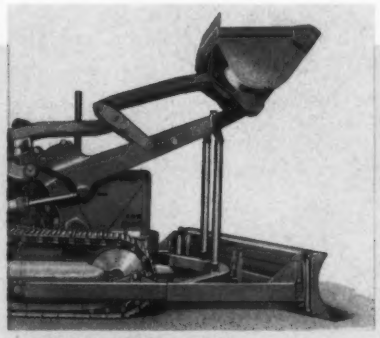
Jobs ahead with these 8 new

TRAXCAVATOR ATTACHMENTS!

Interchange of these attachments is easy and quick. Note the special buckets—each designed for maximum loads of various types and weights of materials. Not only are there "more jobs ahead" for Traxcavator owners, but each attachment will pay a bonus in most efficient material handling. Remember, too, as present owners of Cat-built No. 977, No. 955 and No. 933 Traxcavators, you can get new versatility at low cost with any of these attachments.



STRAIGHT BLADE
You'll use this 'dozer blade attachment on a multitude of jobs—pushing dirt, leveling, clearing, stockpiling.



ANGLING BULLDOZER
Another 'dozer blade—this one angles for backfilling, grading, ditching or any other angling blade 'dozer job.

EXTRA

values in the new TRAXCAVATORS

Exclusive, Automatic Kick-Outs *free operator's hands for steering or gear shifting.*

Exclusive Oil Clutches *give up to 5 times longer life than dry-type clutches.*

3-Grouser Track Shoes *give good flotation and ample traction for good digging.*

Big Load Retention *with tilt-back bucket —40° tilt-back at ground level.*

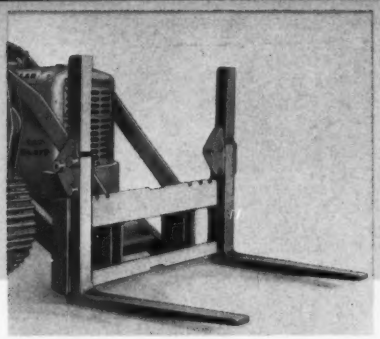
High Dumping *to load high trucks or hauling units.*

CAT 4-Cycle Diesel Engines—*known for dependable, low-cost performance.*

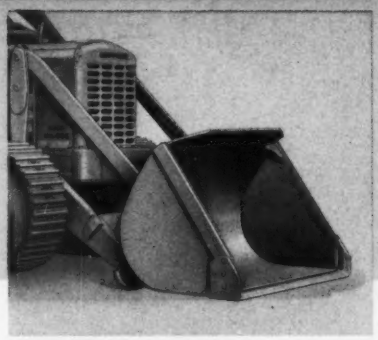
Easy-to-Reach Controls—*one hand operates lift and dump levers simultaneously.*

Efficient Hydraulic Systems *speed operation; vane-type pumps are hydraulically balanced.*

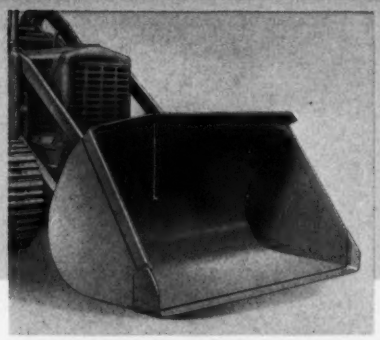
EXTRA



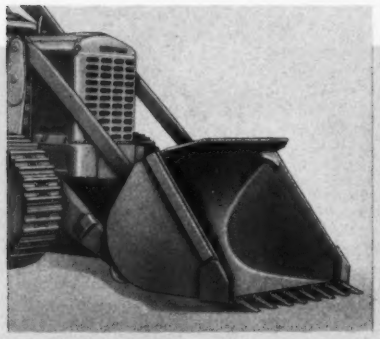
LIFT FORK
Here's a new one that will pay its way on scores of jobs—handling pipe, lumber, skids, steel, etc. The answer to lift-haul needs.



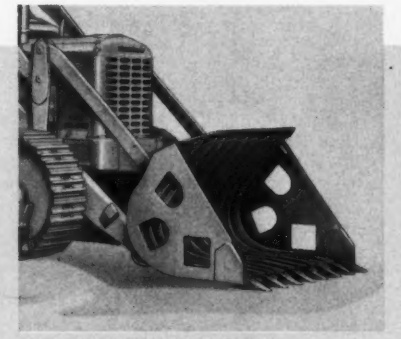
HEAVY-DUTY BUCKET
Designed for the rough, tough digging in hard materials. Bucket edge concentrates maximum power to dig and pry.



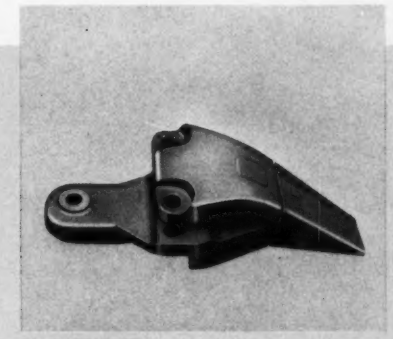
LIGHT MATERIAL BUCKET
Another quick change, and you have a large capacity bucket for high speed loading of loose, light materials.



QUARRY BUCKET
For greater digging penetration in tough materials, this bucket is equipped with teeth with replaceable tips.



SKELETON ROCK BUCKET
For full loads of rock, with dirt and fines sifted, this special bucket is ribbed and sides have openings.



BUCKET TEETH
To shatter hardpan or other tough materials, these teeth bolt on standard and heavy-duty buckets. Tips are replaceable.

Here's Owner Proof of TRAXCAVATOR Profit-ability

Grading and paving contractor loading dirt into trucks for base material and fill—*"My No. 955 will outmaneuver any other type of machine used for this purpose."*

Sub-contractor loading stockpiled rocky clay with a No. 977—*"We actually loaded a 12-yard truck in 1 minute 48 seconds."*

Building contractor loading excess material and leveling—*"The No. 933 has a lot of power for its size. It has good balance and is so stable you can do a good job of close grading and topsoil stripping."*

Sewer contractor using No. 933 for backfilling, loading and laying pipe—*"No. 933 kept three, 5-yard trucks busy hauling only 300 feet."*

General contractor moving 12,000 yards for a filling station—*"No. 955 carries stumps and broken concrete easily. There's no load loss. Machine will have double the life of any comparable machine."*

Gravel and ready mix concrete operator—*"Our No. 955 replaced a loader and back hoe, works faster than both. It'll work circles around competitive machines."*

TRAXCAVATOR SPECIFICATIONS	No. 977	No. 955	No. 933
Engine (four cycle, valve-in-head Cat Diesel)	100 HP	70 HP	50 HP
Standard Bucket Capacity	2¼ cu. yd.	1½ cu. yd.	1 cu. yd.
Dumping clearance (45° discharge angle)	9′ 3⅜″	8′ 3¾″	7′ 10 1/16″
Dumping height (Center of hinge pin to ground)	11′ 9½″	10′ 8″	9′ 10½″
Digging depth (Below ground with 5° initial digging angle set at ground line)	13⅝″	12¼″	10 5/16″
Length	17′ ½″	15′ 1¼″	13′ 10″
Width	8′	6′ 8″	5′ 10″
Height	7′ 3¾″	6′ 10½″	6′ 3¼″
Weight	31,795 lb.	21,480 lb.	15,500 lb.

FOR TRAXCAVATOR FACTS SEE YOUR **CATERPILLAR DEALER**

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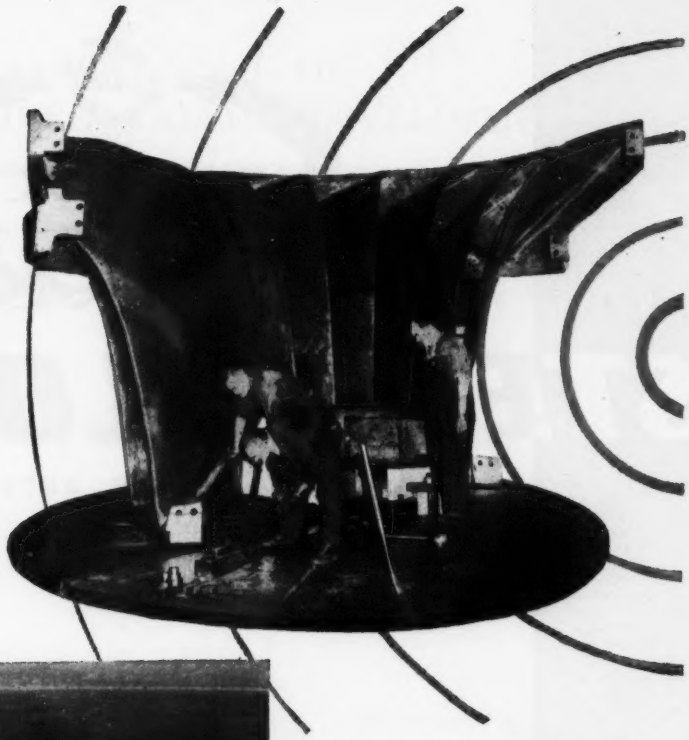

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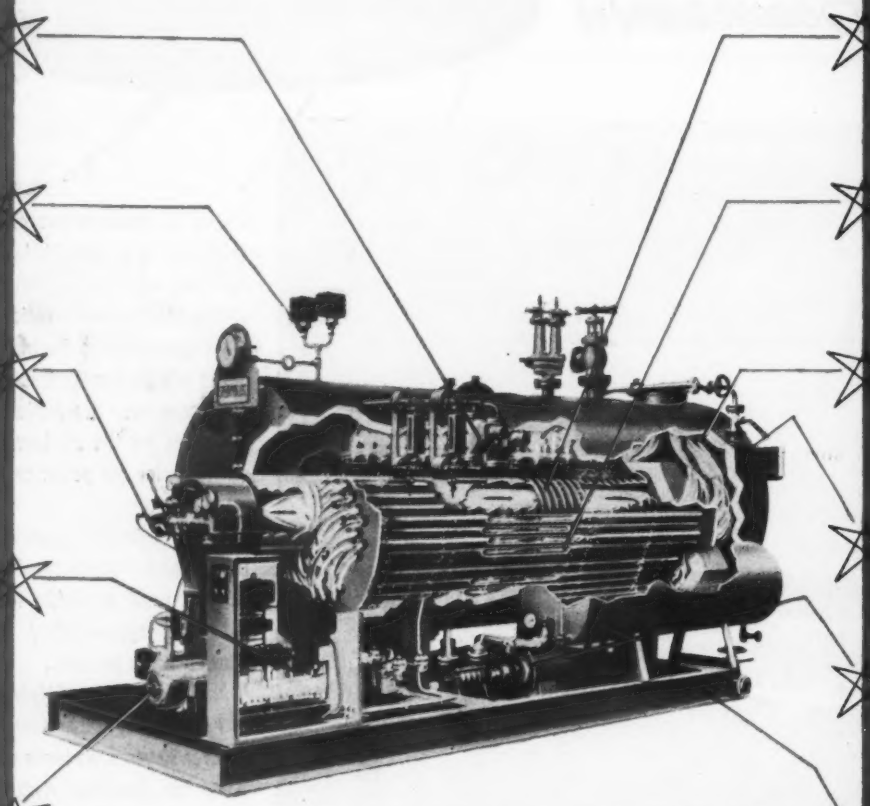

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Editor : K. K. Sinha

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Vol. VII FEBRUARY 1957 No. 2

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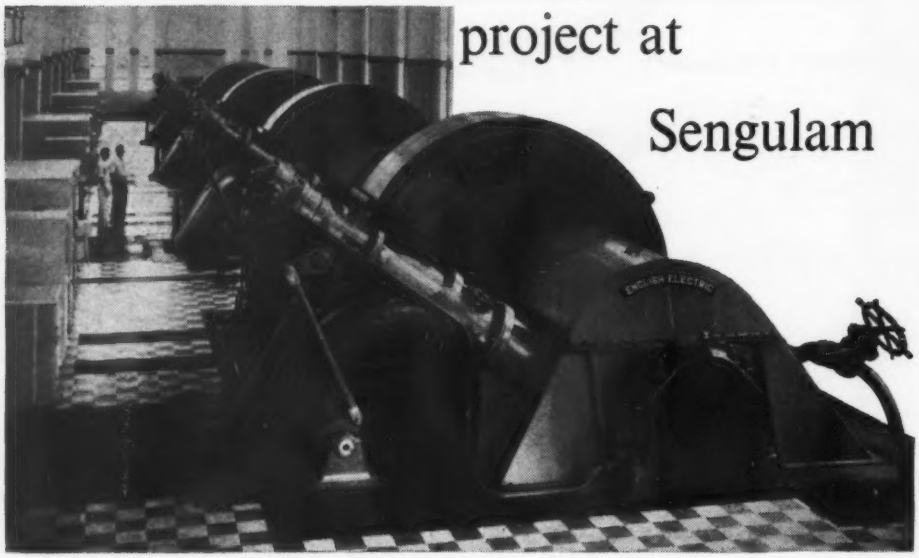
Comprehensive hydro-electric project at Sengulam



The entire plant and equipment for the Sengulam Power Station in Kerala, India, was supplied by The English Electric Company. The equipment included four 36 in. dia. cylindrical-balanced high-pressure inlet valves; four 12 MW, 1,120 ft. head, 500 r.p.m. turbo-alternator sets; four 11/66 kV transformers; 66 kV and lower-voltage switchgear and control panels; and additional switchgear at the Pallivasal Switching Station.

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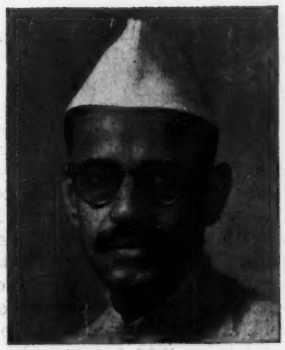


By G. L. NANDA
Minister for Irrigation and Power, Government of India

With his unaided physical efforts man can secure for himself nothing more than a pitifully low standard of living. As population grows recourse to every available source of energy for maintaining a reasonable level of living becomes imperative. Among various such sources, electricity has come to occupy an outstandingly important position. Electricity has become the symbol of civilization and a measure of our material progress. It is accepted as an essential basis and concomitant of the growth of industry. There is increasing recognition also of its importance for agriculture and rural development.

We in India have during recent years made a considerable advance in electrical development. The *per capita* generation in this country has doubled itself over the last 8 years or so, which indicates a rate of growth that is comparable to that in the industrially advanced countries. However, in respect of actual magnitude of the *per capita* generation which is now taken as 25, India stands very low in the scale of development. The actual *per capita* generation in this country in the year 1953 (for which figures are readily available) was 18.51 units. On a *per capita* basis, Britain produces 88 times, U.S.A. 162 times and Norway 360 times, compared to India. This is an indication of the leeway our country has still to make up.

Our immediate Plans

A total generating capacity of one million kilowatts was added during the first Five Year Plan bringing the total installed capacity in the public utility undertakings in India to 2.7 million kilowatts. Among the projects which were taken up during the first Five Year Plan and which are expected to yield substantial benefits in the second Five Year Plan, are the Bhakra Nangal Project in which an installation of 450,000 kW of generating capacity will be installed, the Gandhisagar power station under the Chambal Scheme and the Rihand Project. The commissioning of the Hirakud Power Station on the 13th of this month marks an important milestone in the progress of power development. We have embarked upon a more ambitious programme of power development during the second Five Year Plan. 44 Hydro-electric and Steam generating schemes are to be undertaken in this Plan. Of these, 25 will be Hydro-electric Stations and 19 Thermal Power Stations. Among the new hydro-electric schemes taken up during the second Five Year Plan may be mentioned the Sharavathy Project which has immense possibilities. Though the installation of the two units of 71,000 kW each has been proposed for the second Five Year Plan, the ultimate capacity of this power station will be more than 710,000 kW. Among the steam power station slated for completion during the second Plan, the 150,000 kW station at Durgapur, 90,000 kW station at Korba, 200,000 kW station for burning the lignite fuel at Neyveli and the extensions to the Bokaro and the Trombay power stations are worth mentioning. With the successful completion of these projects in the second Five Year Plan, an additional generating capacity of 3.5 million kilowatts will have been added. This represents a marked advance over the first Five Year Plan, in which a generating capacity of one million kW was added. Besides these power generation schemes, 35,000 miles of transmission and subtransmission lines, of voltages varying from 220 kV to 11 kV have been planned. The total outlay on power projects in the public sector, during the second Five Year Plan, will be about Rs. 427 crores, as compared with Rs. 160 crores in the first Five Year Plan. The private electricity companies are expected to invest another Rs. 42 crores.

When we look ahead we can visualize a mounting demand for power in the country, to match the ambitious plans for all round economic and industrial development of the country. We find that our load surveys worked out on the basis of past experience, quickly turn out to be underestimates and our targets have to be revised upwards. We thought at the beginning of the First Plan that we should, over a period of 15-20 years, add seven million kW. It appears to me that in actual fact the increase may exceed twice that figure. It is obvious that in the coming years there will occur a vast expansion of energy generation in the country. The question arises whether we have in sight adequate basic resources for the purpose.

India's Power Resources

We have a number of rivers, large and small, spread throughout the country. Even though their flow is seasonal, considerable hydro-power can be developed if they are harnessed properly. In the context of planned development, systematic assessment of the resources of the entire country becomes imperative. In planning, it is not sufficient to be assured merely that schemes undertaken are technically and economically sound but also that sufficient data are made available to enable the selection of the

best alternative for providing the intended benefit to the particular region under consideration.

Hydel Resources

The need for a rational assessment of the hydro-electric power resources of our country was realised as early as 1917-18. According to the investigations then conducted, the hydro-electric potential of the Indian sub-continent, based on the minimun flow, was estimated at only 3.5 million kW. In view of the rapid expansion of the power supply industry, it was found necessary to undertake a more systematic study of the hydro-electric potential of the country. The greater demands for electric power permit larger investments on river regulation, thus enabling better utilisation of the energy resources. Modern construction techniques have also opened up possibilities that were outside the reach of early pioneers in this field. The reassessment of the hydro potential now in hand takes into account the possibilities of storage, suitable diversion of watersheds and other such means, with a view to ensuring the optimum utilisation of the available power potential. The preliminary surveys of West-flowing and East-flowing rivers of the Indian Peninsula, the Central India rivers and the Ganga basin have been completed and the work in other areas is in progress. It has been estimated that the hydro power potential of our country is of the order of 35 million kW.

Thermal Resources

In regard to the thermal power resources also, we are very well placed. Although the know reserves of metallurgical coal in India are of the order of 2700 million tons only, the reserves of non-coking and steam coals have been estimated at 40,000 million tons. Besides, substational quantities of lignite are available in South India. It will be reasonable to assume, therefore, that for several decades to come, our resources of coal will adequately meet our requirements. In the past, particularly in the pre-war period, good quality coal was being freely used in the boilers of the power stations.However, it has now been decided to reserve the high grade coals for essential metallurgical purposes and to permit the use of only low grade fuels for burning in boilers. Largely following this policy, we have already built some thermal power stations, designed to use lowgrade, high-ash-content coals. All future thermal stations should be planned on this basis. Regional Advisory Committees have set up for coalfields in different areas in the country, under the auspices of the Fuel Research Institute, to advise the project authorities regarding the characteristics of the coal available in different areas.

Nuclear Power

While it is a matter of satisfaction that we have adequate hydro-electric and thermal power resources for meeting our requirements for some decades to come, it is also important that we should keep ourselves abreast of modern technological developments in other countries. You are all, no doubt, aware that scientists and engineers of Western countries—particularly, U.K., U.S.A., and U.S.S.R. are actively engaged in harnessing nuclear energy for production of power. A 5,000 kW nuclear power plant was commissioned in the U.S.S.R. a few years ago, and recently, the Calder Hall nuclear project supplying some 50,000 to 60,000 kW of power to the Electricity Grid in U.K. was brought into commission; in due course, the output of this station is expected to exceed 100,000 kW. The British Electricity Authority have placed further orders for 300,000 kW nuclear power stations to be established in different parts of the country. Efforts are also in progress for the construction of power stations based on nuclear fuel in the U.S.A. and in Canada. It is a matter of satisfaction that we have adequate resources of radioactive materials in our country. As an experimental measure, the Atomic Energy Department are actively considering the question of setting up a nuclear power station of about 140,000 kW at a suitable location in India. The generation of energy at this station may be costlier than hydro or thermal power generated in a large modern high-pressure station. However, in due course, improved techniques and designs might enable further economies to be effected, making the cost of power generated in a nuclear power station comparable and competitive with that in a conventional thermal power station located at some distance from the coalfields. It is, therefore, most important that we keep ourselves abreast of studies and research in the field of atomic energy.

Evening the disparities

The progress in the field of power development has not been uniform in the various regions in this country and there is much to be done in the interest of regional justice. Taking for example, the criterion of *per capita* consumption, regions like Orissa and Assam with *per capita* consumption of .49 and .7 units respectively are far too under-developed compared to other States like Mysore and Bombay with *per capita* consumption of 56 and 51 respectively. These regions of Orissa and Assam are by no means poor in resources; but those resources have to be harnessed. It should, therefore, be our endeavour in planning, to even out the disparities of development in the various regions progressively. No doubt, the development in other spheres such as industry has also to be planned in those backward regions, if the demand for power has to develop. A proper load survey of the country which takes into account the possible development of the resources of the regions, is valuable for planning. A start in this direction has already been made and load surveys in the various are being conducted by the Central Water and Power Commission.

Plant Manufacture

Another very important aspect of power development is the manufacture of heavy plant and machinery. With all the development programmes under way we cannot afford to depend on foreign countries for our requirements of plant and machinery. Apart from the heavy burden it puts on our foreign exchange resources, dependance on other countries for the plant and equipment will result in a lop-sided development. The amount of indigenous manufacturing capacity in this country is far from adequate and is confined to the manufacture of smaller items. The decision to establish the heavy electrical factory at Bhopal is therefore, I believe, the first step in the right direction.

Rural Electrification

With a predominantly agricultural population dwelling in the 560,000 villages in India, we would not have achieved much if the benefits of electricity were

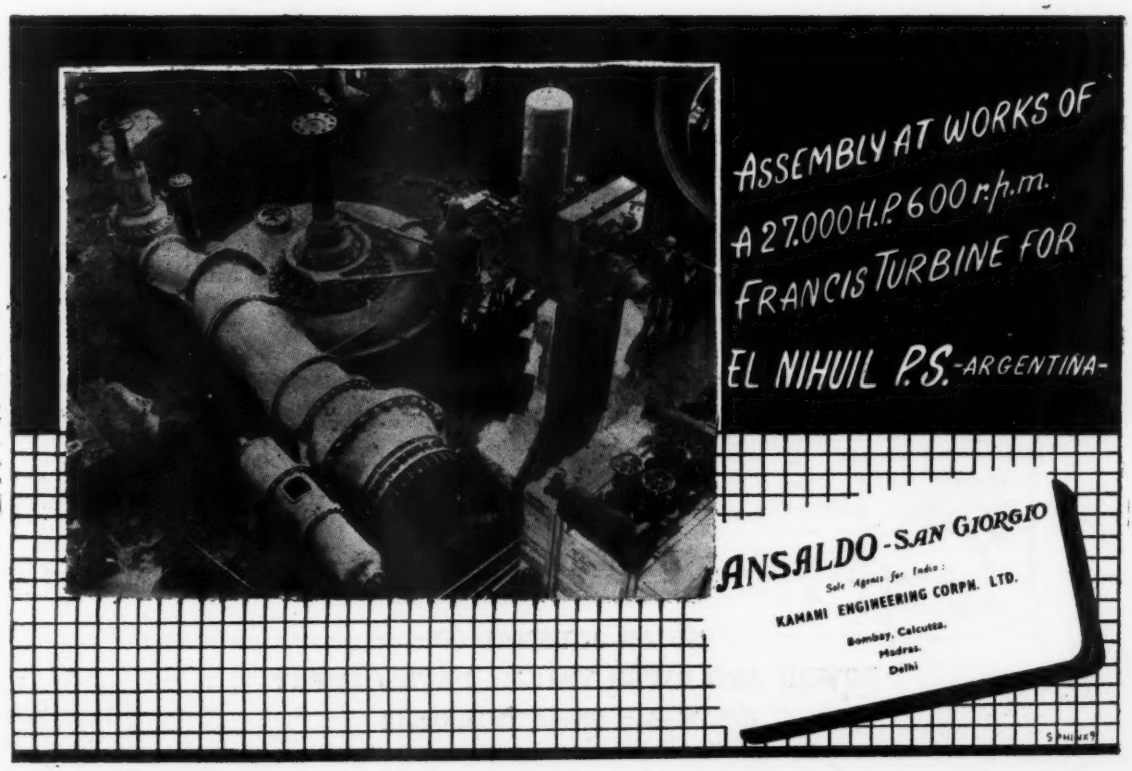
made available to the rural areas. Rural Electrification, therefore, assumes very great importance in our power development programme. The number of villages which were served by electricity at the beginning of the first Five Year Plan was only about 3000. This figure has been doubled during the first Five Year Plan and we are planning to carry electricity to about 10,000 more villages and and small towns during the second Five Year Plan at an estimated cost of Rs. 75 crores. Even with this increase, the number of villages electrified by 1960-61 would form hardly 3 per cent of the total in the country. We have thus touched only the fringe of the problem and we may have to give more attention to this in the future. This problem of rural electrification is beset with certain difficulties as these schemes are not usually self-supporting and some kind of direct or indirect subsidy has to be thought of. But, with the general improvement in the standard of living in the country in course of time, a more rapid expansion of rural electrification can be anticipated.

Technical Personnel

Adequate and suitably qualified technical personnel at the various levels is a pre-requisite for efficient and timely execution of any development project. An assessment of the availability of the technical manpower has brought home the fact that the existing institutions for technical training are entirely inadequate and that a net-work of technical institution and training centres has to be opened to train the large number of technical personnel required for the execution of the Plan. In addition to the creation of adequate facilities for training of technical personnel, the question of research is also engaging our attention. There are a vast number of problems which are met with in the day-to-day work of electricity undertakings to which solutions have to be found. Extensive research in this field is carried on, not only by the large manufacturers of electrical plant and machinery abroad but also by certain organizations like the ERA in U.K. who undertake research on specific problems referred to them by the utilities or manufacturers. Collossal sums of money are spent on this kind of applied research in the advanced countries, and it is that which has led to the advancement in the techniques, that characterises this age. This aspect cannot be neglected and the earlier we make a concerted effort in this direction the better it would be.

I have taken advantage of the opportunity to touch on a few matters which have an essential bearing on the problem of power development in the country. The agenda you have before you for the Conference comprises questions of great practical interest, and I am sure your discussions will be helpful in securing a speedy, efficient and balanced utilization of the power resources in our country. The Power Engineers of India have a creditable record in the past. Achievements of a much higher order await them in the future.

Being the inaugural address at the Second All India Power Engineer's Conference, held at Bangalore in January, 1957.



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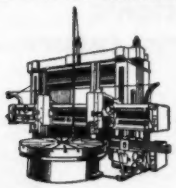

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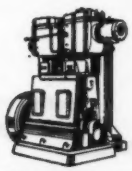

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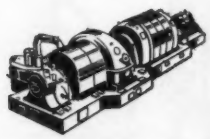

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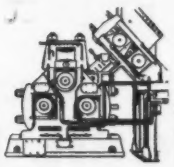

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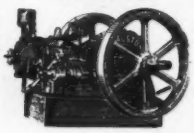

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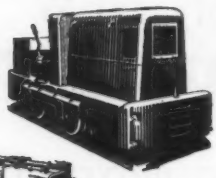

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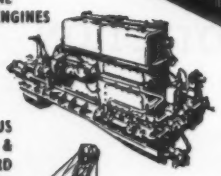

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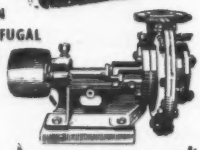

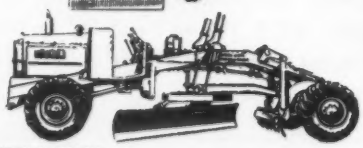

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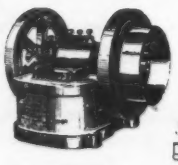

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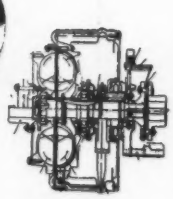

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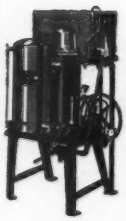

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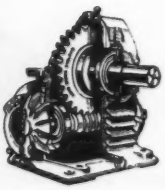

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Yellow River Basin Multipurpose Project: An Outline

By CHENG HSUEH-MING, B.Sc.,
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The Yellow River, known as "China's Sorrow" in the past, originates in Chinghai Province and empties into the Pohai Bay on the north-east coast of China. The whole length of the second largest river in China is 4,845 km. It has a drainage area of 745,000 sq. km., and a total drop of elevation of 4,368 m.

Upstream of the Lungyang Gorge (Chinghai Province) is called the upper reaches of the Yellow River. The upper valley, about 1,100 km. in length, is covered with forestry and vegetation and the flow carries little silt.

The middle reaches of the Yellow River extend about 3,000 km. from the Lungyang Gorge to Taohuayu (Honan Province). This stretch of the river is further divided into four small sections according to the different characteristics of each.

From the Lungyang Gorge to the Tsingtung Gorge (Kansu Province) is the first small section, where deep gorges are formed in alternation with plains of different sizes along the river's course. The gorges mostly consist of metamorphic shale, gneiss and igneous rocks. The slope of the river bed is steep. Annual rainfall ranges from 200 to 300 m.m. The average flow in this section is 1,019 c.m.s., the flood peak of 0.1% frequency is 8,330 c.m.s., and the annual silt discharge is about 100 million tons.

The second small section, extending from the Tsingtung Gorge to Hokoucheng (Inner Mongolia), is characterized by flat and wide open river channels. The river bed consists of thick layers of silt and loess. The annual precipitation is less than 200 mm. The flow slacks here and river slope is very gentle. The average flow at Paotow in Inner Mongolia is is 829 c.m.s., and the flood peak of 0.1% frequency is calculated at 6,400 c.m.s. Due to the use of water for irrigation, evaporation loss and the effect of channel storage, both the average flow and the flood discharge are less than those of the upper stretch. The annual silt discharge at Paotow is 150 million tons.

The third small section, from Hokoucheng to Ymenkou (on the border between Shensi and Shansi provinces), is a deep canyon of several hundred kilometers, with many rapids and cascades. The north and south ends of the canyon are composed of limestone karst formation, and interlayers of sand stone and shale. The annual precipitation is 400 mm. The average flow at Lungmen is 953 c.m.s., with the flood peak of 0.1% frequency 36,800 c.m.s. The annual silt discharge is 830 million tons. The numerous tributaries which join the Yellow River in this section cause a big increase in flood flow and silt discharge as well.

The fourth small section extending from Yumenkou to Taohuayu is the farthest downstream and also the most important gorge section of the river. It has a wide variety of geological formations: loess, porphyrite, sandstone, shale, quartzite and limestone. The average flow at Sanmen Gorge is 1,300 c.m.s., and the flood peak of 0.1% frequency is calculated at 37,000 c.m.s., with an annual silt discharge of 1,380 million tons.

Below Taohuayu to the sea about 700 km. in length are the lower reaches of the Yellow River, traversing the great sedimental loessial plain created by the by the river itself. As the river slope is very flat, the gradual deposition of large amounts of silt has continuously raised the river bed which is usually higher than the adjacent plain. In some localities it may be 3 to 10 metres higher.

The flood discharge along this stretch of the river is kept inside its channel by a complicated system of dykes. The width of high water channel between the dykes varies greatly. In Honan Province, it opens up to 20 km., while in Shantung Province, it may narrow down to only half a kilometre. This abnormal layout of the dyke system makes the floods in the lower reaches even more difficult to control.

The flood menace of the Yellow River is notorious. as can be traced from various historical documents, there occurred more than 1,500 dyke breaches in the past 3,000 years. The river shifted its course appreciable 26 times and changed its course entirely nine times. Indeed the floods of the Yellow River were a constant threat to the safety of the 80,000,000 people inhabiting 250,000 sq. km. of fertile land.

Apart from serious floods, the Yellow River also brings another grave menace—the loss of water and soil in its middle reaches and serious drought in the whole basin. The drought of 1929 which ravaged the basin affected the lives of 34 million people.

Drilling being done on the dam site of the Sanmen Gorge project on the Yellow River

In the middle reaches of the river is the largest loess region in the world. Here a considerable quantity of soil is lost every year, especially during heavy downpours. In the areas most seriously affected, every sq. km. annually loses 10,000 tons of soil. In the middle reaches as a whole, some 3700 tons of soil are carried away per sq. km. annually. As a result, the average amount of silt carried by the Yellow River in Shenhsien, Honan Province for example, is no less than 34 kg per cubic metre. During floods the greatest amount of silt carried reached 580 kg per cubic metre. Evidently, the Yellow River is a river most heavily laden with silt in the world. Soil erosion, gone on for many years, has gradually reduced the arable land in the area and cut down the fertility of the soil and yield of crops.

After liberation a great amount of work has been carried out on the Yellow River. The work can be divided into two categories. All the measures aimed at relieving the imminent threats of flood fall into the first category ; namely, the strengthening and raising of the dykes, and the setting up of two flood-retarding areas in Shantung Province. Thus the precarious situation of the Yellow River has been changed, and the security of life and property in its lower reaches has been ensured in the last few years. The maximum flow in 1954 reached 14,000 c.m.s., but no damage was done. On the contrary, in 1934 when the maximum flow was only 8,500 c.m.s., the river breached the dykes in four places and inundated land in six counties. In 1935, when the maximum flow was 13,300 c.m.s., the Yellow River made a large breach in the dyke and over-ran a dozen counties in Shantung and Kiangsu provinces. More than two million people were affected by that flood.

Of course, the dykes cannot be relied upon as a permanent protection against flood. A more fundamental solution has to be found. With this point in view, an all-out survey has been conducted of the Yellow River basin since 1950. This work falls into the second category. It includes reconnaissance, surveying, geological investigation, drilling, hydrological observation and surveys of regional economy. The all-out survey covered the main river from the Lungyang Gorge to the sea, and many important tributaries. An expedition to the source of the river and a general reconnaissance of the loessial regions were also conducted.

Up to 1954, 16,000 km. of the main river and its tributaries, including their headwaters had been reconnoitred ; an area of more than 85,000 sq. km. were surveyed ; 100 tentative dam sites along the main river were inspected ; 344 borings, totalling 13,015 m. in depth were drilled at 27 dam sites ; economic investigation of 11,000 sq.km. of reservoir areas were made ; and a mass of hydrological data of the past decades was systematically collated and analysed. At its peak, 3,000 persons were engaged in the work. It was due to these efforts that the fundamental and reliable data required for the development of the Yellow River were compiled.

In 1954, with technical assistance from the Soviet Union, a multiple-purpose plan was successfully drawn for the complete harnessing of the Yellow River.

An Outline of the Yellow River (Hwang Ho) Plan

1. *The Fundamental Principles of the Yellow River Plan*

The fundamental principles of the multiple-purpose plan to harness the Yellow River have been laid down in accordance with the characteristics of the Yellow River basin and the needs for development of our national economy.

(*a*) To control flood, which has remained a serious but unsolved problem for many centuries, will be given first priority in the multiple-purpose plan for the Yellow River basin.

(*b*) To develop irrigation of farmland in the Yellow River basin in order to increase agricultural production.

(*c*) To supply electricity to the newly established industrial and other enterprises in the Yellow River basin.

(*d*) To improve navigation on the Yellow River.

(*e*) To carry out on a large scale the water and soil conservancy work over the vast loessial regions in the Northwest in order to lengthen the life of the reservoirs and prevent channels in the lower reaches from being silted up.

2. *Main Feature of Plan—Cascade Development Scheme*

A main feature of the multiple-purpose plan of the Yellow River based on the above principles is to develop the main course of the river as a continuous cascade, the stages of which will consist of 46 dams. Five of the dams with large regulating reservoirs will have the multiple purpose of flood control, irrigation, power generation and navigation ; six of them will be only diversion projects mainly for irrigation ; while the remaining will be for power generation.

Sixteen dams will be constructed along the stretch between Lungyang Gorge and Tsingtung Gorge. Four of them will function as multiple-purpose projects (Liukia Gorge being one of them). The rest will be for power generation. In this stretch water power is given the main emphasis while the problems of flood control, irrigation and navigation are of subsidiary importance.

In the next stretch between the Tsingtung Gorge and Hokoucheng, irrigation and navigation are most important. Four dams will be built for irrigation.

In the third stretch between Hokoucheng and Yumenkou, all the fifteen dams will be for power generation.

Ten dams will be constructed in the fourth stretch between Yumenkou and Taohuayu. The most important among the series mentioned above is the Sanmen Gorge project, giving the highest benefit in flood control, irrigation, power gneneration and navigation.

In the last stretch, two dams which will mainly regulate the discharge from the power plants above stream for irrigation, will also be built between Taohuayu and the mouth of the river.

Among the 46 dams, five including the Sanmen Gorge, the Liukia Gorge and three irrigation dams, have been selected as the first-stage-development projects. (All the projects in the first-stage-development of the Yellow River will be completed before the year 1967).

Description of Various Aspects of the Multiple Purpose Plan

(*a*) *Flood Control*

After the completion of these first-stage-development projects the flood threat of the whole Yellow River will have been entirely relieved ; the Sanmen Gorge project will have freed the lower stretch of the river from flood menaces just as the Liukia Gorge project will have removed the threat of inundation of Lanchow, the newly developed industrial centre in Northwest China.

(*b*) *Irrigation*

The prospective plan calls for the development of irrigation on 9.8 million hectares of land in the Yellow River basin. Further expansion is restricted due to the deficiency of water. In other words, all the water in the Yellow River will be utilized in the future. Schemes of diverting water from the Yangtze or other rivers in order to increase the irrigation area in the Yellow River basin have also been considered. Before 1967 about 2 million hectares of land will be irrigated. (Owing to the rapid progress of national economic development this figure will be increased). The provincial quota in hectares are : Chinghai 14,000, Kansu 137,000, Inner Mongolia 281,000, Shensi 151,000, Shansi 60,000, Honan 640,000, Hopei 267,000 and Shantung 467,000. Improvement on existing irrigation systems will be effected on 8,000,000 hectares of land. On the main river three diversion dams will be built for irrigation.

(*c*) *Power Generation*

Altogether 23 million kW. of electric power will be installed in the 46 projects with total annual output of 110,000 million kWh, equivalent to ten times the the country's total electricity generated in 1954. Consequently, abundant and cheap power will be supplied to the various industries, communication, and the modernized agricultural activities in the provinces of Chinghai, Kansu, Inner Mongolia, Shensi, Shansi, Honan and Hopei. Electrification of this vast region will contribute to the saving of a large amount of coal.

The construction of the Sanmen Gorge and the Liukia Gorge projects, with a generating capacity of a million kilowatts each, will be started within the next two years.

(*d*) *Navigation*

According to the plan navigation on the Yellow River will be greatly improved.

The proposed first-stage-development will render about 1,800 km. of the Yellow River navigable. The waterway would consist of the following stretches : (1) from Taohuayu to the mouth of the river 703 km. ; (2) from Ninchuan (Kansu) to Chinshuiho (Inner Mongolia), 843 km. ; (3) the Liukia Gorge and Sanmen Gorge reservoirs.

Drilling being done on the Liukia Gorge project on the Yellow River.

(e) *Water and Soil Conservancy*

Water and soil conservancy measures cover many fields including forestry, animal husbandry and hydraulic engiueering. These measures will not only reduce the silt-content in the discharge but will also benefit agricultural production in the loessial regions. As the agricultural co-operation movement grows, more reasonable use of farmland will be made possible. The cultivation of steep slopes and devastation of vegetation will be stopped ; farming methods will be improved, the erosion of fertile top-soil prevented and precious rain water retained. These measures will naturally lead to the increase of agricultural production and will ensure the growth and prosperity of the agricultural co-operation movement.

In the Plan, water and soil conservancy work will be carried out throughout the region where soil erosion takes place. During the first-stage-development only the most severely eroded regions will be treated. Besides the measures mentioned above, a number of reservoirs, mainly for silt detention, will be built on some of the tributaries most heavily laden with silt. It is estimated that the silt carried in the Yellow River will be reduced by half and agricultural production will be doubled after the completion of the first-stage-development of water and soil conservancy work.

4. *Sanmen Gorge and Liukia Gorge projects*

A. Sanmen Gorge Project—Located about 20 km. east of Shenhsien (Honan Province), the Sanmen Gorge project will possess the largest reservoir on the Yellow River. It is strategically located and is the only project which can effectively solve the most pressing problems of the Yellow River.

The area controlled by the Sanmen Gorge project will make up 92% of the entire drainage area of the Yellow River. Which the normal high water level at El. 350 m. above Taku Datum, the capacity of the reservoir will be 36 cubic kilometres. Should the normal high water level be raised to El. 360 m., the capacity would be increased to 65 cubic kilometres. With such a big reservoir, the multiple-purpose functions of the Yellow River Project can very well be achieved.

(1) First of all, the Sanmen Gorge project can reduce the maximum flood (Q 0.1%) of the Yellow River from 37,000 c.m.s. to 8,000 c.m.s. and even to 6,000 c.m.s. This discharge can safely pass the narrowest sections of the lower reaches. The remaining 8% of the drainage area not controlled by the Sanmen Gorge may still produce flood waters higher than the lower channel can carry, so the reservoirs on the tributaries I, Lo and Sin are also necessary to solve the flood problem of the Yellow River completely.

(2) Irrigation of the lower Yellow River basin can greatly increased by regulating the water of the Sanmen reservoir. During the first-stage-development 1,340,000 hectares of land will be irrigated and 4,650,000 hectares later.

(3) One million kilowatts of electric power will be generated by the Sanmen project, with a corresponding annual energy production of 4,600 million kWh which will satisfy the industrial, agricultural and other needs of Shensi, Shansi and Honan provinces.

(4) The navigation facilities in the lower reaches of the river can be greatly improved.

(5) The huge Sanmen Gorge reservoir will be able to detain a large volume of silt, which is very necessary especially during the period before water and soil conservancy work has produced appreciable effect in reducing lsoil erosion. This will prevent further silting of the river bed in the lower reaches. Flood control irrigation as well as navigation will be made possible as a result of the reservoir.

The geological and topographical conditions of Sanmen Gorge are favourable. The dam site consists of hard and dense igneous rock (porphyrite). With a thickness of 80 metres and high compressive and abrasive strength, it forms a satisfactory foundation for the projected high dam.

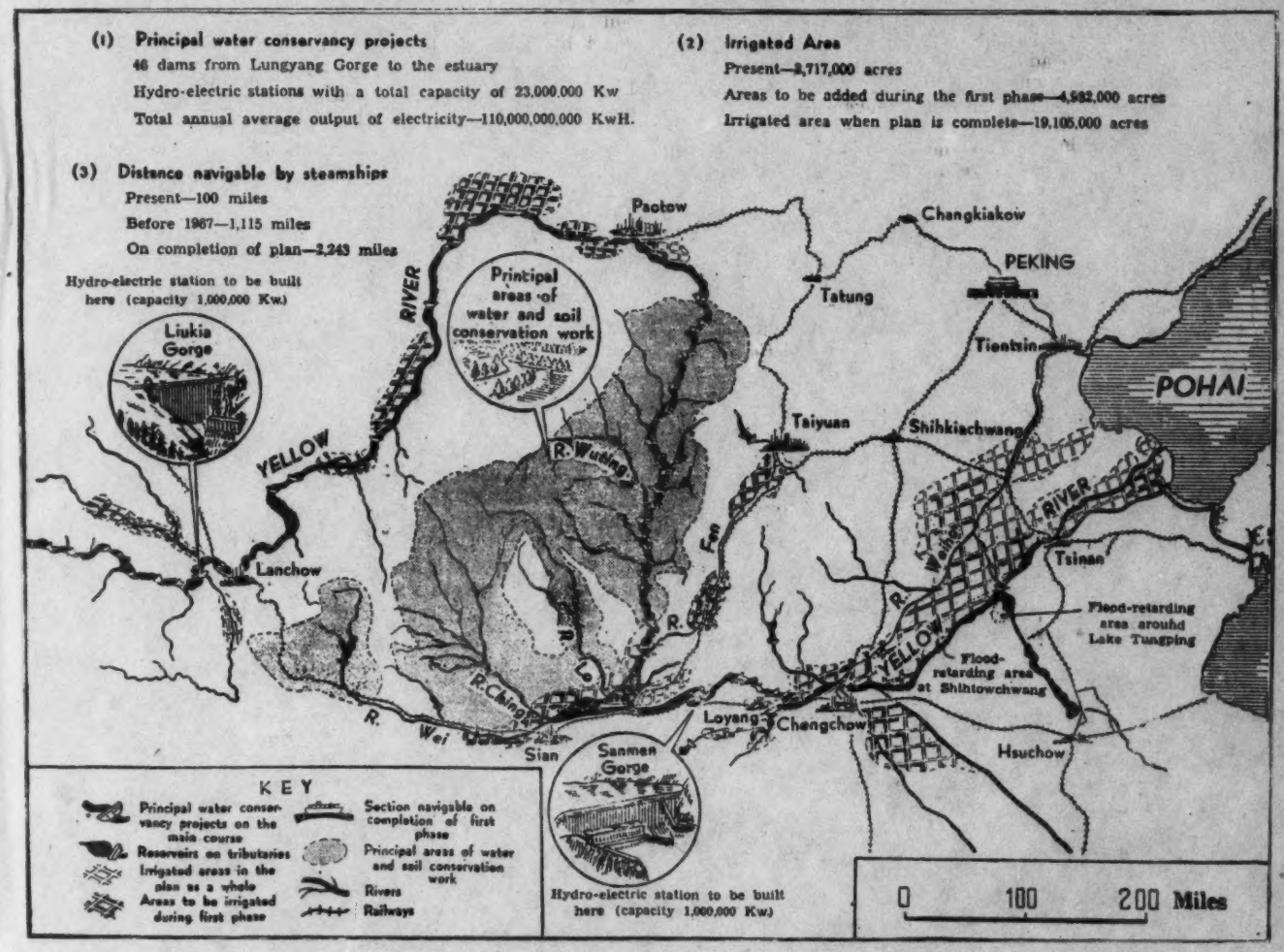
Assuming a normal high water level at El. 350 m., the height of the dam will be 90 m., and the total volume of concrete will be 2 million cu.m.

The width of the river channel at Sanmen Gorge is about 400 m. Standing mid-stream are two large rocky islands which divide the river channel into three. These rocky islands can be used as a part of the cofferdams during the construction period.

There are only 17 km. between the dam site and the nearest railway station ; the transportation facilities of the Sanmen Gorge project are therefore very convenient.

The total construction cost including all the compensation costs of reservoir inundation and railway relocation of the Sanmen Gorge project is about 1,220 million yuan, a very small cost compared with the huge benefits the project will bring. The consstruction of the Sanmen Gorge project will be started in 1957, and completed in 1961. For the time being, vigorous preparatory work is being carried on.

B. Liukia Gorge Project—Located at 60 km. west of Lanchow, the dam site is in a deep and narrow gorge, with a width of 45 metres at the water's surface. The sun's rays seldom reach the bottom of the gorge. The height of the projected dam is about 120 metres. The capacity of the power plant, like the one at Sanmen Gorge, is a million kilowatts, with an annual energy output of 5,230 million kWh, which will supply industrial, agricultural and other needs in Lanchow and its surrounding regions. The reservoir capacity of the Liukia Gorge project is 4.9 million cubic metres. Besides generating electric power the project will minimize the flood menace to the Lanchow industrial district and will supply water for irrigation and navigation in the Ordos area. Since the gorge is very narrow at the dam site, the preliminary estimated cost of construction of the Liukia Gorge project amounts to only 530 million yuan, which is one of the lowest among the hydro-power stations on the Yellow. (*Exclusive.*)


(1) Principal water conservancy projects
46 dams from Lungyang Gorge to the estuary
Hydro-electric stations with a total capacity of 23,000,000 Kw
Total annual average output of electricity—110,000,000,000 KwH.
(2) Irrigated Area
Present—2,717,000 acres
Areas to be added during the first phase—4,582,000 acres
Irrigated area when plan is complete—19,105,000 acres
(3) Distance navigable by steamships
Present—100 miles
Before 1967—1,115 miles
On completion of plan—2,243 miles
Hydro-electric station to be built here (capacity 1,000,000 Kw.)
Liukia Gorge
YELLOW RIVER
Printipal areas of water and soil conservation work
R. Wuding
R. Lo
R. Ching
R. Wei
Lanchow
Sian
Paotow
Changkiakow
PEKING
Tatung
Tientsin
POHAI
Taiyuan
Shihkiachwang
R. Fen
R. Sz
Tsinan
Flood-retarding area around Lake Tungping
Flood-retarding area at Shihtowchwang
Loyang
Chengchow
Hsuchow
Sanmen Gorge
Hydro-electric station to be built here (capacity 1,000,000 Kw.)
KEY
Principal water conservancy projects on the main course
Reservoirs on tributaries
Irrigated areas in the plan as a whole
Areas to be irrigated during first phase
Section navigable on completion of first phase
Principal areas of water and soil conservation work
Rivers
Railways
0 100 200 Miles

Problems of Design of large Turbine Generators

By D. H. HARMS, M.V.D.E. M.A.I.E.E., M.C.I.G.R.E
Chief Design Engineer A.E.G.

The apparently unsaturably demand for ever increasing power has made it necessary to develop and build turbo-generators with continuously increasing ratings. Whereas 25 to 30 years ago the maximum output of 2-pole machines was in the range of 40 to 50 mW, today for large generators these figures have more than doubled and approach even upto five times those earlier ratings.

On the other hand we must keep in mind that due to the high speeds and correspondingly high stresses in the rotating parts the dimensions are limited and therefore the question arises how this increase in output has been achieved. With the indicated limitation in the physical dimensions of large modern turbo-generators the required large ratings can only be materialised through a corresponding increase of the specific magnetic and electric loading. Since, due to saturation the magnetic loading can be enlarged to a very limited extent only the increase of electric loading i.e., amps/inch armature circumference is therefore mainly responsible for the considerable increase in output of a given model. To which extent this has been accomplished may be shown by the following table :

Table 1

Year of manufacture	1925	1935	1950	1956
Specific weight in ton /MVA :	2.8	2	1-8	1.5
Specific active volume in cft/MVA	11	8.6	6.6	5

The mechanical problems will be considered first because of their predominance in turbo-generator design. Let us, therefore, first investigate the stresses created by the centrifugal forces in the rotating parts.

Mechanical stresses

Assuming a rotating disc to consist of a number of independent rings the tangential stress in each ring increase with the square of the diameter as indicated in fig. 1 (figures are printed separately). The largest stress therefore occurs in the outer region ; it decreases to zero in the centre. Actually, however, rotor is one solid piece and there- fore the different ring elements are held together.

For this reason the centrifugal forces of the outer elements are partly transferred into the inner ones and due to this the stress distribution inside the rotating body is changed entirely as indicated in Fig. 2. The tangential stress now has its peak value not on the outer surface, but in the centre. The transfer of stresses between the different ring elements is evidenced by the radial stresses.

With a rotor-diameter of 1.1 m the maximum tangential stress at the bore at 3000 rpm amounts to 40,000 lbs/sq. inch. During overspeed test which according to German standards has to be carried out at 125% of rated speed the stress will go to 62,000 lbs/sq. inch. Since the yield point of the forging material employed for high speed, large turbo rotors is in the vicinity of 85,000 lbs/sq. inch there is an abundant margin of safety even during overspeed tests.

However, within the last years a number of failures on large turbo generators have taken place and these failures, although none of them happened in Germany, have led to a thorough and critical investigation of stresses, property and composition of the steel. It may be stated here that in none of the cases overstressing has been the cause of the defects. Instead inhomogeneity, tendency towards brittleness and stress concentration are said to have been found responsible. For this reason it may be of interest to explain how rotors, used by my company, are manufactured.

The billet from the ingot mould has approximately twice the finished weight. Since it is recognised that inclusions of gases particularly of hydrogen cause internal cracks and brittleness, a leading German steel mill has succeeded in pouring the billet under vacuum. As shown in fig. 3, the solubility and with that the hydrogen content decreases with decreasing pressure.

How large an H_2 content can be tolerated in order to prevent internal cracks can be explained by Fig. 4. These considerations have not only theoretical interest but can practically be substantiated. This is indicated in Fig. 5, showing the H_2 content in different

liquid steels before and after the evacuation. The practical way of carrying out vacuum pouring is illustrated in Fig. 6. There are of course other ways in the process of manufacturing forgings by which inclusion of H_2 can be minimized. However, none seems to be so effective, particularly for large forgings as the vacuum pouring process. With this practice of manufacturing and with a very minute testing of specimen as well as constantly checking the composition besides thorough inspection by the ultrasonic method and last but not least by applying the overspeed test reliable big forgings are obtained.

Although the revolving rotor has in a number of cases led to disaster, still more stressed are the retaining rings which have to support the end-windings of the rotor. These retaining rings cause already an appreciable stress by their own mass, whereas the additional stress from the end windings which have to be supported amounts in the largest rotor to only 40% of the total stress.

Hence already 60% of this centrifugal force is caused by the ring itself. Obviously such a ring can be manufactured more reliably than a large piece rotor weighing 40 and more tons.For reasons of losses in the vicinity of the end windings these rings must consist of non-magnetic steel. For such a material the required mechanical property i.e., strength, can be obtained by cold working only. This cold working was formerly, and in a good number of foreign countries is still today, carried out by forging the rings on a mandrel at rather low temperatures (450 to 500°C). German steel manufacturers are carrying out this cold working in a special hydraulic device and by doing so are obtaining a high degree of homogeneity. This manufacturing procedure represents a severe test since with the hydraulic device the entire ring is stressed well beyond the elastic limit or yield point. It will therefore burst in case it should have defects.

As may be gathered from corresponding publications, the failure of several retaining rings is certainly caused mainly by unreliable manufacturing process and partly by stress concentrations. Referring again to a 1.1 m diameter rotor, the retaining ring stress amounts to approximately 58,000 lbs/sq. in. at rated speed, i.e., 88,000 lbs/sq. inch at 25% overspeed. The yield point of the austenitic non-magnetic cold worked retaining ring, is in the order of 125,000 lbs/sq. inch. This gives a similar margin of safety as the rotor body, as far as stress is concerned.

Due to shrinking on the rings additional stresses are created as shown in Fig. 7.

Vibrations

As we have seen, the stresses have limited the rotor diameter to approximately 1.1 m., Any increase in the physical dimensions was therefore almost exclusively achieved by increasing the length. That again reduced the critical speeds since a good number of years well below the operating speed. So during start and shut down those critical speeds have to be passed.

Today the first critical speeds of the largest modern machines are even below 1000 rpm and in the same manner this has also reduced the second critical speed to such an extent that it comes into the region of operating speed. Keeping further in mind that the generator rotor never runs alone but is coupled to the turbine rotor, it is essential to investigate the higher critical speeds of the entire set. Fig. 8 shows the different critical speeds of a uniform three bearing shaft as well as its deflection curves. In this simple case there is, of course, symmetry with respect to the middle bearing.

For an actual turbo-set such symmetry does not exist and to calculate the corresponding values of critical speeds as well as the deflection curves is only possible with an electronic device. Figure 9 shows the result of such an investigation for a modern turbo-set. The dominating influence of the generator rotor on the running condition can clearly be recognized from the curves.

For this reason proper balancing of the rotor is of of vital importance for obtaining smooth running conditions ; and this balancing can successfully be carried out only in a dynamic balancing set.

Figure 10 shows as an example the magnitude and phase angle of the vibration amplitude after balancing has been completed in an adequate balancing set.

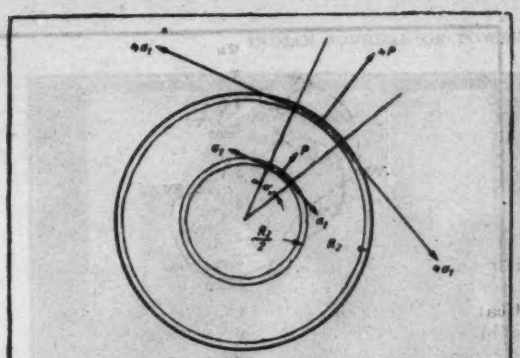
Lossess and Efficiency

From previous considerations we know that the growth of single units is mainly accomplished through an increase in the electric loading. The insulating material permits only a limited temperature and therefore the increase of loading goes hand in hand with the improvement of heat dissipation. The two possible ways for increasing the output are therefore : either the specific losses are reduced and therefore the amount of heat dissipation is likewise reduced, or by improving the ventilation more heat can be dissipated with the given temperature drop. Both possibilities have been made use of in the past.

Fig. 11 shows that the specific losses of large turbo generators have been reduced to less than a half of their value within the last 30 years. This improvement has been achieved by numerous means. A very decisive cut in losses was brought by the employment of hydrogen cooling. Since the windage loss with large air cooled machines was in the range of almost 50% of the total losses, the introduction of hydrogen brought this figure down to a negligible amount.

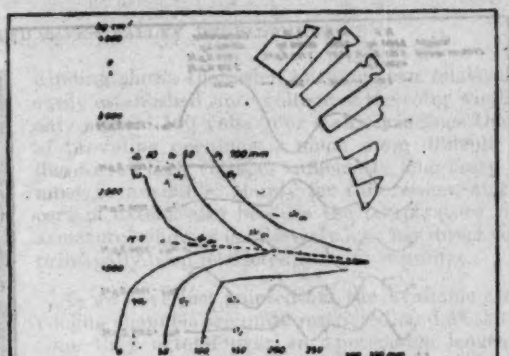
A further improvement of efficiency was accomplished by employing a more favourable construction for the end windings and their support, since the additional losses originate in this part of the machine. By means of specially alloying and annealing the punchings the core loss also has been decreased remarkably.

Although this appreciable reduction in total generator losses looks at first sight sufficient to prevent dangerous temperature of the insulating material, it must not be forgotten that the generator dimensions have been decreased still more and therefore reduced the heat dissipation surface or in other words, in spite of the reduced specific loss heat dissipation per unit surface has been increased. For this reason in order to prevent overheating, ventilation had to be improved.



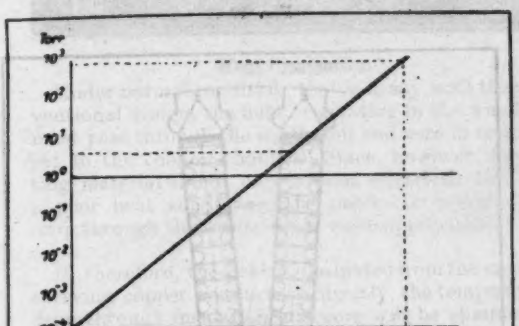
AEG — Tangential stress in rotating disks — TV 56 2567

Fig. 1



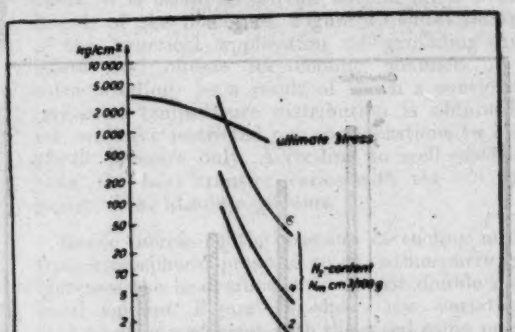
AEG — Distribution of stresses in a rotor with 1.1m diameter at 3000 R.p.M. — TV 56 2568

Fig. 2



AEG — Solubility of H_2 in liquid steel at different pressures and 1600°C — TV 56 2571

Fig. 3

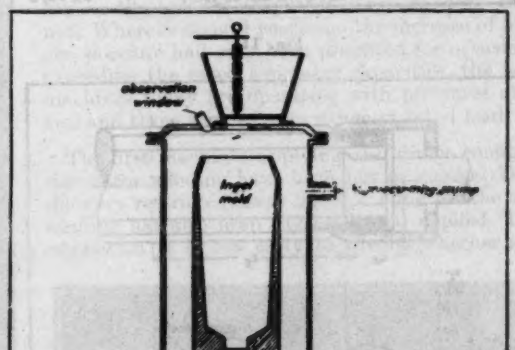


AEG — H_2-pressure in ordinary steel at different temperatures — TV 56 2570

Fig. 4

AEG — H_2-content of liquid steel before and after evacuation — TV 56 2572

Fig. 5



AEG — Principle of vacuum pouring — TV 56 2573

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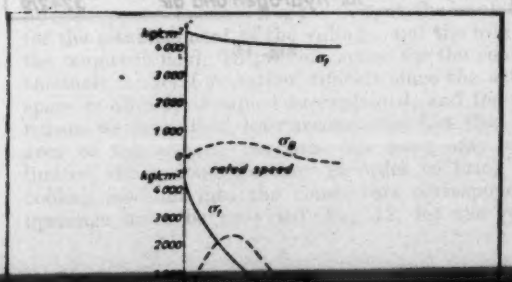
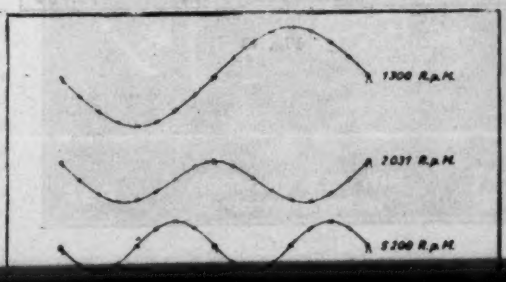
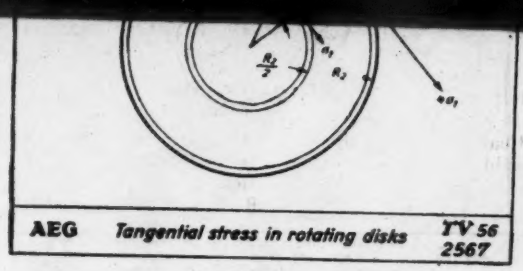
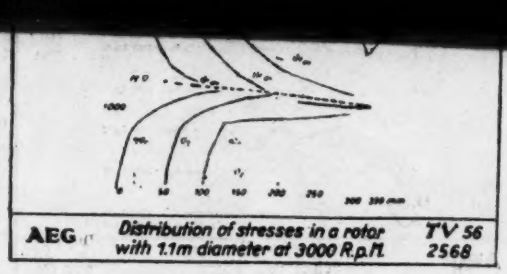






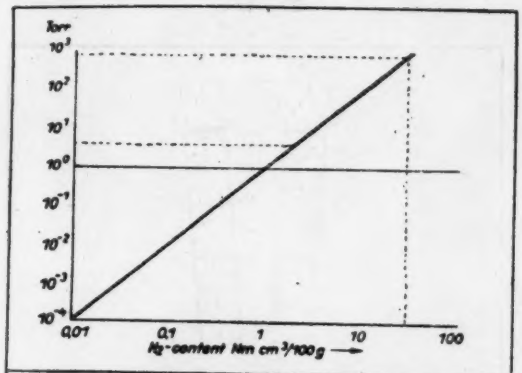
AEG Tangential stress in rotating disks TV 56 2567

Fig. 1



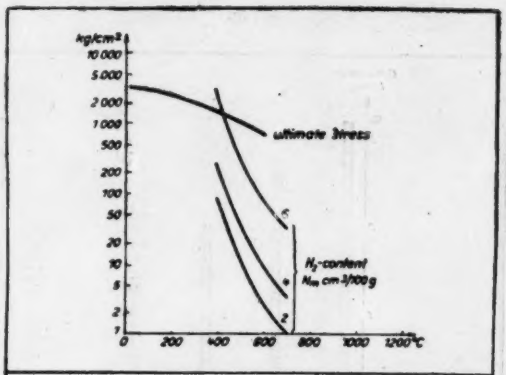
AEG Distribution of stresses in a rotor with 1.1m diameter at 3000 R.p.M. TV 56 2568

Fig. 2



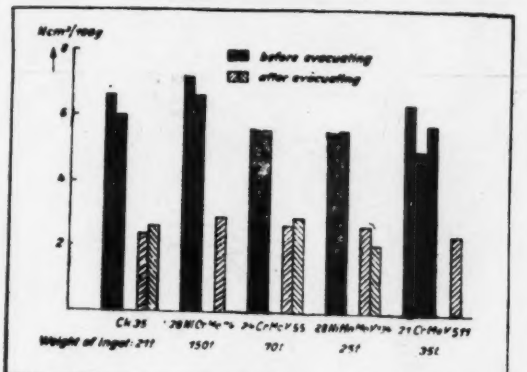
AEG Solubility of H_2 in liquid steel at different pressures and 1600°C TV 56 2571

Fig. 3



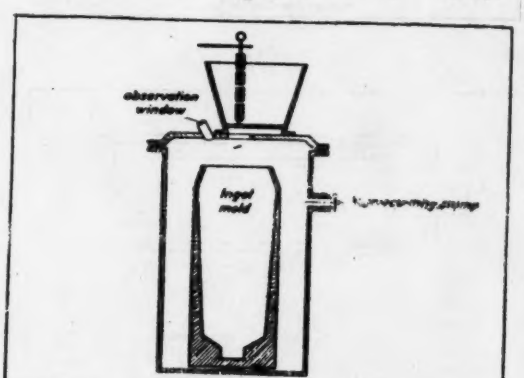
AEG H_2-pressure in ordinary steel at different temperatures TV 56 2570

Fig. 4



AEG H_2-content of liquid steel before and after evacuation TV 56 2572

Fig. 5



AEG Principle of vacuum pouring TV 56 2573

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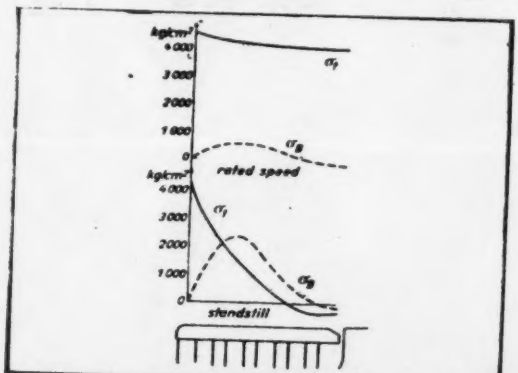
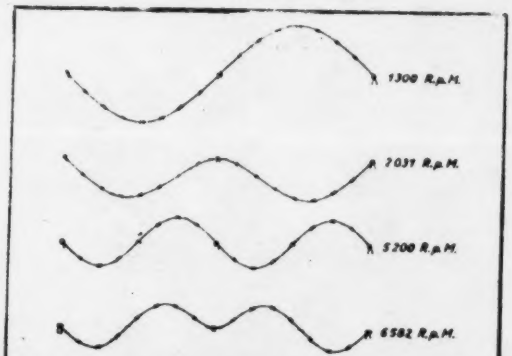


AEG Stress distribution in a retaining ring TV 56 2575

Fig. 7



AEG Shaft deflection curves and critical speeds of a uniform 3 bearing shaft TV 56 3244/9

Fig. 8

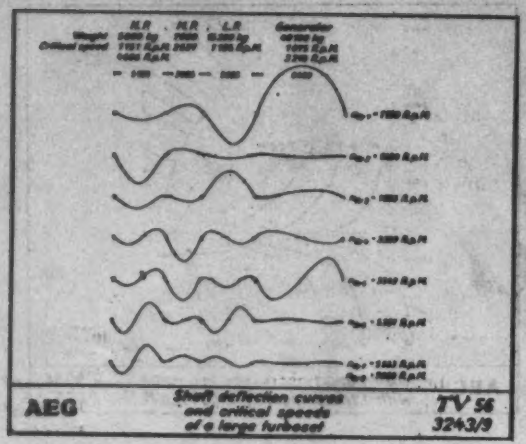


Fig. 9

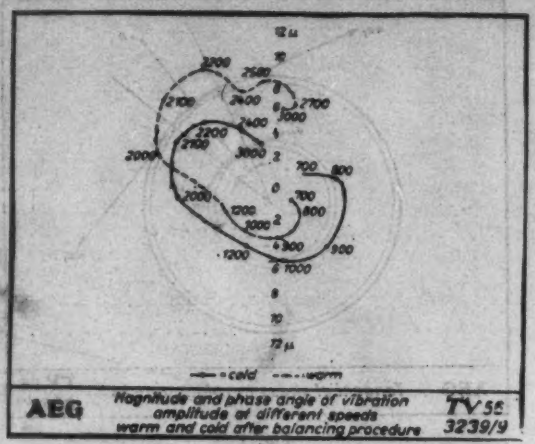

cold
warm
AEG
Magnitude and phase angle of vibration amplitude at different speeds warm and cold after balancing procedure
TV 56 3239/9

Fig. 10

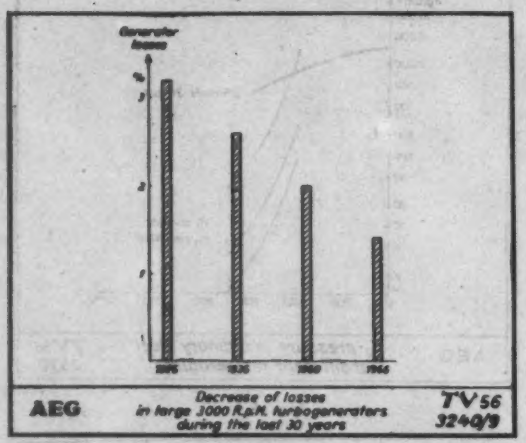


Fig. 11

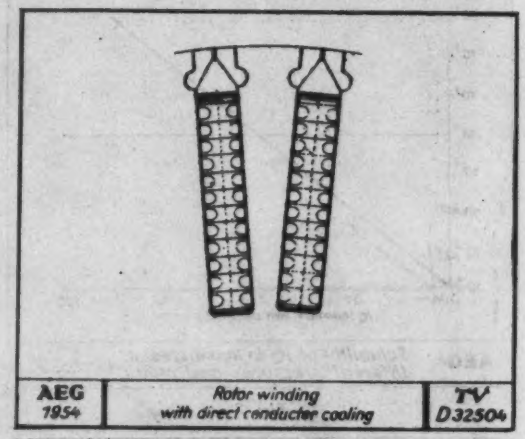


Fig. 12

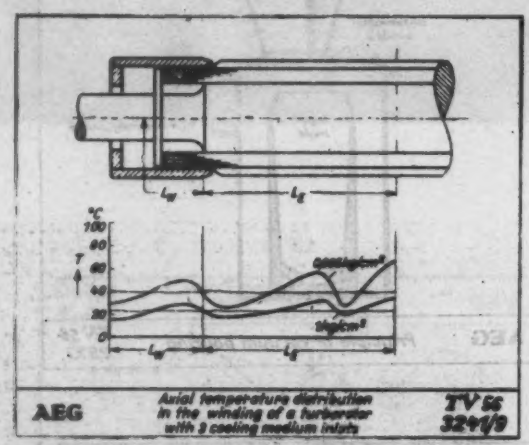


Fig. 13

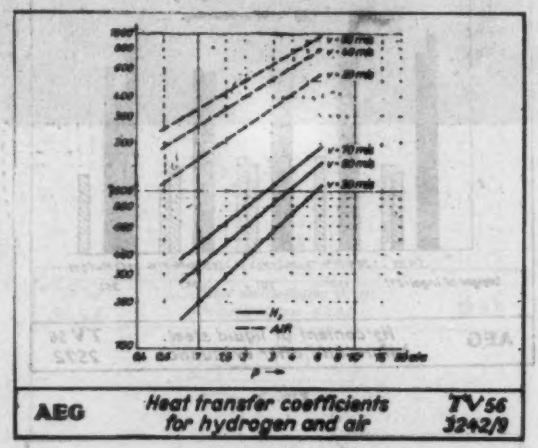
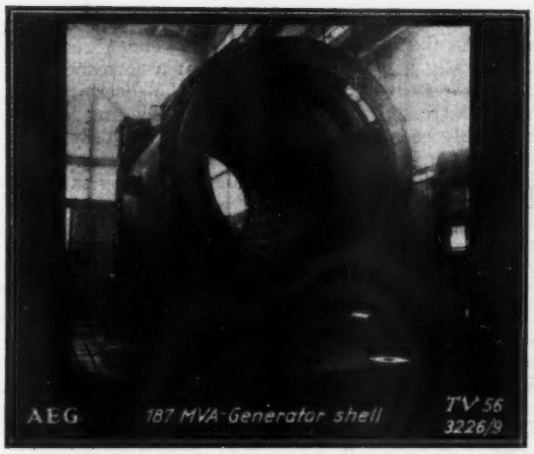


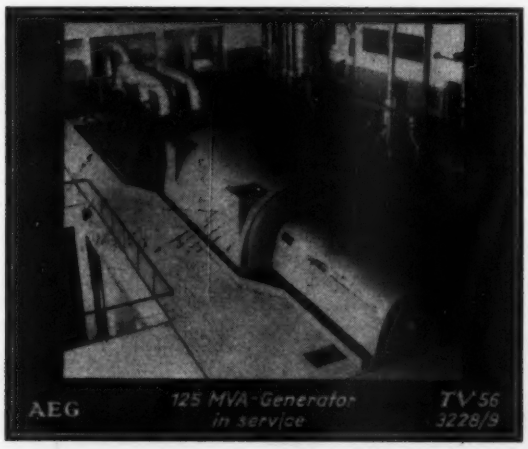
Fig. 14



Heat dissipation

Under normal condition, that is to say, with the conventional design, the heat originating in the windings must pass through the insulation and core in order to get to the cooling channels. Since, however, insulating material is not only a poor electrical, but also a poor heat conductor, the necessary temperature drop through the insulation is quite appreciable.

If, therefore, the heat is dissipated from the current carrying copper conductors directly, the temperature drop through insulation and core will be eliminated. This kind of cooling is termed direct cooling and is nowadays employed on all large trubo generators.



The difficulties in practically applying this direct cooling are manyfold.

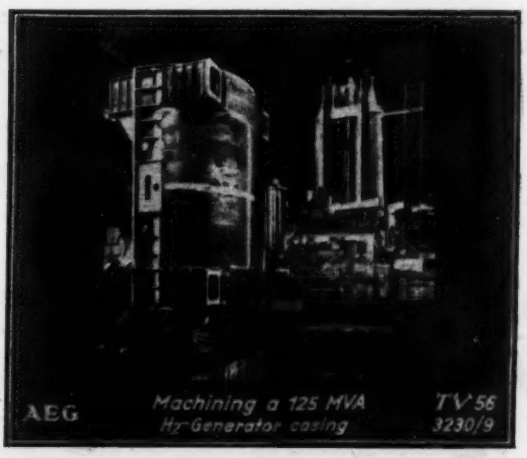
First it must be borne in mind that the available space in the active part of the machine is occupied by the copper for conducting the current, the insulation for the establishment of the voltage, and the iron for the magnetic field. To provide space for the cooling channels is therefore rather difficult since the active space is already occupied as explained, and for this reason we must take into account the fact that the area of the cooling channels can have only very limited dimensions. Further in order to bring the cooling medium into the conductors corresponding openings must be provided. Fig. 12, for the rotor winding shows that such openings can relatively be easily established since voltage of the rotor winding is only several 100 volts. For stator windings the task of providing openings is much more difficult since due to the high voltages sufficiently long creep ways must be available. Mainly for this reason, and to a certain extent also because the temperature rise of armature windings is relatively low, has direct cooling principally been restricted to rotor windings.

As we have just pointed out the available areas of cooling channels are quite restricted, and at the same time they extend over an appreciable length. For this reason the cooling medium in passing through the channels will be heated up by a certain amount, so that the temperature of the escaping gas is correspondingly increased. In order to minimize this effect, it is useful to provide several inlets over the length of the machines. Figure 13 shows the result of the practical application of providing several inlets and outlets for cooling channels in the rotor winding, as a result of which a considerably improved temperature distribution is obtained. So far, we have restricted our considerations to atmospheric pressure only. According to well established laws, the heat transfer varies with the 0.8 to 0.9 power of the absolute pressure.

Hence increasing the pressure of cooling medium from atmospheric pressure to one atmosphere gauge increases the heat transfer to almost double its original amount. Figure 14 shows the variation of heat transfer coefficient with the speed using pressure as parameter.

But besides improving the heat transfer, the gas temperature rise by passing through the narrow channels, is decreased because the heat capacity has been enlarged. This is indeed a very active tool for raising the specific output of large modern machines. Whereas several years ago the increase of hydrogen pressure had only been practised for occasionally exceeding the rated generator capacities, the largest machines today are operating with pressures of one, two and three atmospheres gauge at rated load.

The first machines applying also direct cooling for the stator winding have been put in service. Due to the very restricted areas liquid cooling for the stator winding has also been suggested and applied. In my estimation it is too early to predict whether stator



windings of future large generators will be cooled by gas or by liquid. Practical experience will decide this question.

The problems of cooling large generators request the investigation of a number of other problems. There are, for instance, the terminal outlets for the stator windings which must not only insulate but also keep hydrogen tight. Another vital problem is the conducting of the considerably increased rotor current through slip rings and shaft.

Summary and Outlook

I hope I have succeeded in explaining how the tremendous increased demand for large units has been accomplished. I have shown that for mechanical reasons (stress as well as vibration) the dimensions can be increased by a very limited amount only. I have also shown how by applying better material and construction as well as hydrogen as a cooling medium the generator losses have been reduced, and finally how by development of a corresponding cooling system and application of the direct cooling under increased pressure the specific loading has remarkably been increased. That this is not only green theory can be proved by the number of units which have been put in service and are operating satisfactorily. I will not forget and freely state that there were at the beginning drawbacks, but from these we have learned and the last machines have shown no defects.

Further development work in the direction indicated is constantly being carried out. With the data available we are able to satisfy present demand. I will not make any prediction with regard to the the largest possible rating of large generators, since I believe that there are still possibilities for improvement. (*Being a talk delivered at BEST, Bombay.*)

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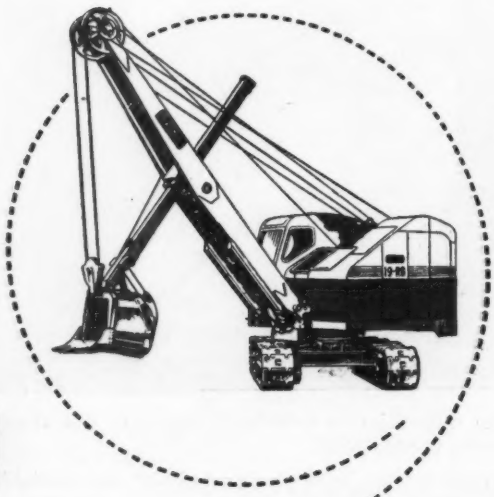

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GC-31

Thoughts on Irrigation and Valley Development in the U.S.A.

By C. S. PARTHASARATHY,
Assistant Chief of Division, Irrigation and Power, Planning Commission, Government of India

The author of this note had been to the United States recently to study some aspects of irrigation development in that country. Being responsible for planning and scrutinising the irrigation projects in this country, he was naturally in a receptive and reflective mood and was wondering to what extent experiences in the States could be of advantage in the future development of projects in his own country. The following very brief notes by him on some of the problems and practices in irrigation and valley development may therefore be interesting to our readers.—Editor

Water Lifts

One of the notable achievements in the field of water resources development in U.S.A. that has made a deep impression on me is the great heights to which projects envisage or have accomplished lifts of storage or underground waters by means of pumping. At the Grand Coulee Dam in Washington State, as much as 16,000 second-feet of water are pumped from the reservoir to a height of 280 feet. Again, under the irrigation system of the Central Valley Project in California, which is linked with the reservoir behind 602 ft.-high Shasta Dam, 4,600 second-feet of irrigation waters are pumped through a height of 197 feet. Of course, cheap hydropower is available in the vicinity of works for undertaking such tasks.

Interbasin Diversion

Interbasin diversion of river waters has also been fairly often promoted and adopted in quite a number of river valley development projects such as the Colorado-Big Thompson Project, Colorado; the Central Utah Project, Utah, designed to utilize the State of Utah's share of the waters of the Upper Colorado Basin, in a neighbouring basin in Utah; the Central Valley Project in the State of California which visualizes the exportation of the surplus waters of the Sacramento River in the north for use in water-deficient areas in the San Joaquin Valley in southern California.

Shasta Dam, California

World's largest pumps lift water 280 ft. high at the Grand Coulee Dam into a 27-mile long storage reservoir

Surface and Ground Waters

To a fairly great extent, there has been closely integrated development of the surface and underground waters in a region or area. It is interesting to note that while the surface water potential in the streams of the State of California is about 71 M.A. ft., its groundwater resources is estimated at about 130 M.A. ft. On top of this, there is at present an over draft on this vast groundwater potential. Consideration is frequently given, in the stage of planning and design of irrigation projects, to the re-use of water in those hydrographic units which are geographically so situated as to enable the rediversion of return flows from upstream works.

Local Interests

I have observed a high degree of interest and exhibition of responsibility on the part of the local community or interests in water resources development designed, among others, for irrigation, municipal and industrial purposes. In the State of California, I believe, a favourable political climate for local community water development exists. It is my feeling that this environment, expressed through laws and policies of Federal and State Governments, appears to have contributed to the healthy and commendable formation of local organizations such as Irrigation or Water Conservancy Districts or Water Users' Associations to cope with and resolve water problems. How interesting and heartening it is to be informed that there are as many as 2,500 such organizations in the State of California; The local co-operative requirements and the local interests' share in the cost of a project are sometimes specified in the project report or in the authorizing Act of the Congress.

Commercial Ventures

In the case of multi-purpose river valley projects, capital costs allocated to flood control, navigation, and recreation are "non-reimbursable". No interest is charged on the capital (construction) cost allocated to the head "Irrigation". However, prior to construction of an irrigation canal system, repayment contracts should be made and finalized with local organization or interests, such as Irrigation or Water Conservancy District. After the construction phase by a Government agency such as the U.S Bureau of Reclamation, the canal system is transferred to the local organization for operation and maintenance, but the title or ownership to the works remains with the Government. I observed while visiting one of the multipurpose river valley projects in California that although the main dam and barrage, 7 miles downstream, have been completed, the construction of irrigation canal taking off from the barrage has been deferred for want of a repayment contract with the local interests who have raised certain objections with regard to the cost of water deliveries. It left me wondering whether or how such a thing could happen in India; The reason is not far to seek. Here, development of irrigation and reclamation of lands is undertaken on a commercial basis with a sharp eye on favorable returns, although there is a certain element of subsidy in meeting the cost of irrigation works.

Cost Estimates

As in India, the cost estimates of the larger river valley projects, it appears, are revised from time to time owing to change in the scope of projects, increase in prices of material and labour, etc.

Water Rights

In quite a number of the Western States in U.S.A., it appears appropriation rights of water use are highly respected and take precedence over riparian rights.

Who will build America's Power?

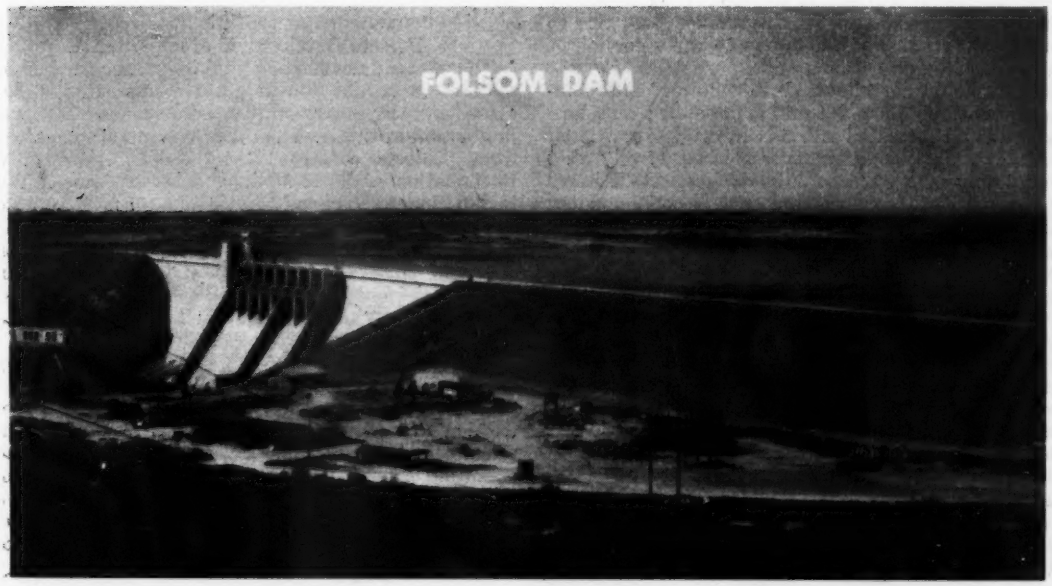
One of the most raging controversies in U.S.A. is

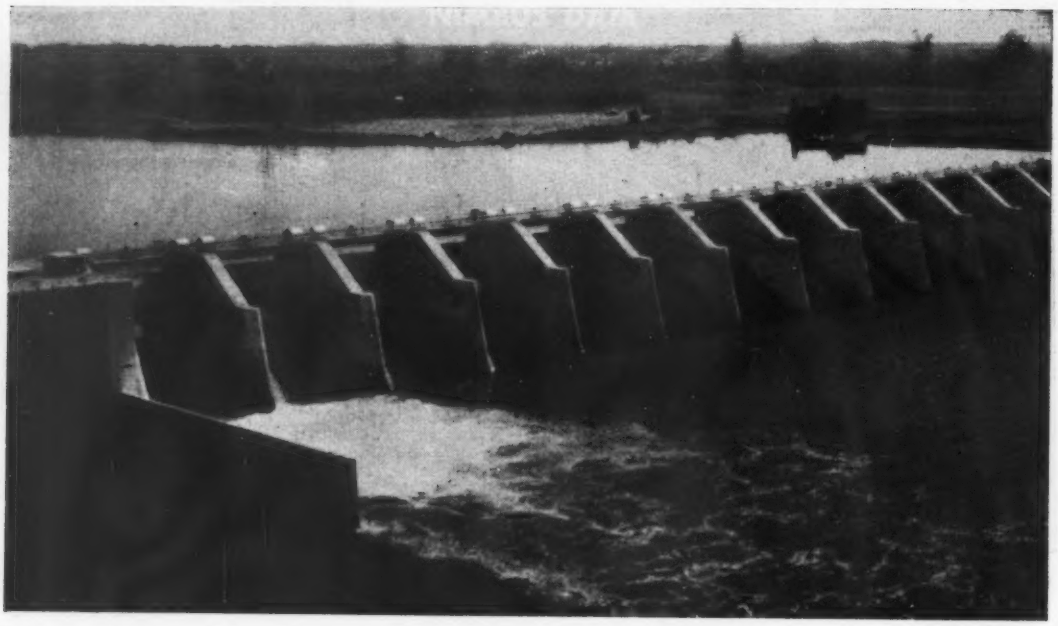
Irrigation Canal from the Grand Coulee Dam Outlet

that of public versus private power. There is also the "partnership" philosophy of power development. This was posed as one of the issues in the recent American elections. One group takes the line that somehow government can do things for its citizens better than the people can do and manage for themselves. A diametrically opposite view points out that it has been free enterprise and private competition under an abiding incentive of profit that has made America to be what it is today. It appears to me that, under the present combination of circumstances and interests obtaining in U.S.A., each conflict between private vs. public power development should be examined on merits and people charged with the task of making those individual and critical decisions should not forget the philosophy of "partnership" venture.

The Snake River development in the Northwest is now hanging fire. The U.S. Bureau of Reclamation has proposed that a high dam at Pleasant Valley in Idaho State which would submerge one of the dam sites approved for private power development is feasible, regardless of the agency for construction. A final decision on this may generate a heated conflict. Another area of dispute appears to exist in building power facilities at Niagara Falls, the point at issue being whether it should be done by the State of New York or private power companies.

Folsom Dam, California





Nimbus Barrage, California

Cost of Power

At present, in respect of may multi-purpose river valley projects, designed and operated by the U.S. Bureau of Reclamation, generation of power is included as a means of making the project a self-supporting and financially solvent undertaking and revenues from power development go to subsidize, either partially or fully, the capital or construction cost of the irrigation facilities. To cite an extreme case, no share of the cost of the 726 feet high Hoover Dam, forming part of the Boulder Canyon Project in the States of Arizona and Nevada, is allocated to 'Irrigation' (development), although water releases from the reservoir (Lake Mead) are made exclusively for irrigation purposes. This naturally gives rise to another divergence of opinion as to what portion of the capital investment on a multi-purpose river valley project should be allocated to "Power" (development) and reimbursed to the Treasury ; and how much should be treated as non-reimbursable or written off as a charge to the taxpayer at large. If only what is equitably or legitimately due is charged to 'Power,' power rates will go down but with a corresponding increased burden on the general taxpayer. The underlying principles in making power bear an additional burden appear to be (*i*) that the revenue-producing parts of a multi-purpose project should bear, in addition to their own, at least a portion of the cost of the "under-privileged" or less promising, but integral, parts of the whole project and (*ii*) the relative paying capacity or purchasing power of the consumers or beneficiaries of the various facilities like power, irrigation, flood-protection, municipal and industrial water supplies, etc. That is why, for exactly the same quantity of the project waters (say, one acre-foot), the consumers of municipal (domestic) and industrial water supplies, generally in the more urban areas, are asked, or prepared, to pay more than the irrigator or the farmer.

Irrigation in the past

In many parts of the West, irrigation systems have been developed in the past largely by private enterprise through cooperative action of water users. In certain cases, due to the fact that higher canals were built later than those built on the lower reaches of a stream, it is rather odd to observe canals running parallel to each other for long distances and only a few hundred feet apart ; and duplicating canal systems and irrigation facilities, controlled by separate irrigation companies, appear to have become common and the original canals built without the benefit of sound engineering, resulting, perhaps, in faulty grades and inadequate control structures.

Present Development of Irrigation

The rate of development of irrigation in U.S.A. appears to be not too rapid. Perhaps this is because of the present status of surplus agricultural production in U.S.A. The total area under irrigation from projects constructed by the U.S. Bureau of Reclamation in the 17 Western States to which their jurisdiction is restricted is only about 7 million acres against a total of about 31 million acres in the whole country with a total area of about 1900 million acres. Compare this with a corresponding situation in India where, out of a total area of about 811 million acres, the area under irrigation is estimated to be about 65 million acres.

Surplus Agricultural Production

I have a feeling that much of the surplus production in agriculture is, perhaps, a result of individuals engaged in non-agricultural business also operating farms with the ulterior objective of using the farm losses and depreciating inventories as a means of writing off the profits in other business. Does that not appear unfair to the legitimate farmer who labors and sweats on the soil ?

Basic Plan of Development

Here is another interesting feature of the basic plan of development of a river basin. In some cases, the regulatory reservoirs proposed in the basic plan are below the points of diversion and they would serve essentially the same purpose as reservoirs upstream of the points of diversion. This is achieved on a basis of exchange of waters or replacement practice which appears to be quite common on streams in the West. By this arrangement, water is diverted upstream in exchange for storage water releases from downstream reservoirs, without affecting adversely the downstream interests or obligations. I imagine there are a few cases of this sort in India under implementation or contemplation.

Benefit-Cost Ratio

A method of benefit-cost analysis made to determine the economic feasibility or otherwise of a river-valley development project is adopted by the U.S. Bureau of Reclamation, although not strictly or expressly required by statutes. The analysis takes cognizance of the widespread effects of the project, not incorporated in other studies. The measurement of benefits from a project namely (*i*) Direct (*ii*) Indirect (*iii*) Public, comprising the increase or improvement in settlement and investment opportunities, community facilities and services, stabilization of the economy, etc., and (*iv*) Intangible (assessed qualitatively), involves an estimate of differences between future conditions, with or without the project. The period of analysis begins with the initial operation of the project and its maximum is taken as the economic life of the project or 100 years, whichever is less. Cost estimates used in the analysis includes interest on the capital investment during the period of construction. If there is any salvage value, it is deducted. Operation, maintenance and replacement cost estimated on an annual basis are added to the construction costs to represent all costs on the cost side of the benefit-cost ratio. Project construction costs are based on prevailing prices and average long-term prices are used for evaluating benefits.

Norris Dam, Tennessee

Land Acquisition

Quite a good number of Americans, it seems to me, are inclined to view with displeasure the tendency on the part of the agencies of the Federal Government who are supposed to own a considerable portion of the land in Western States, to acquire additional land and associated property when executing public works.

Valley Authority

There seems to be no general support for creation of valley authorities such as TVA or DVC in India.

Mr. O. W. Humphreys, Chairman of the Guided Weapons Committee of the Society of British Aircraft Constructors and the Director of the General Electric Company's Research Laboratories in the U.K. had come to India to attend the Commonwealth Standards Conference recently held in Delhi as Britain's official delegate.

He put much emphasis on the importance of setting up atomic power stations in Britain as, in his opinion, they would not only successfully counter the possibility of power shortage arising out of the shortage of coal and oil but also would protect Britain's foreign exchange. He informed that the G.E.C. is building one of the largest atomic power stations in the world.

Asked if within the next 25 years atomic power stations in Britain would replace the existing ones, Mr. Humphreys said "it could happen."

At the Commonwealth Standards Conference in Delhi the experts assembled there discussed common standard of safety and how to improve the various methods. He further informed that efforts to form an international body for this were being made.

Greaves Cotton & Co. Ltd.

On the 31st of March Mr. T. Kemp, Managing Director, and Mr. J. Blezard, Director of Greaves Cotton & Co. Ltd. retire after more than 30 years' service with this Company in India. They joined the Company at a time when its main interests were in the textile industry and have seen these interests grow to cover not only textile machinery but also a very wide range of engineering equipment. They were responsible for guiding the Company successfully through the difficult post-war years and in building it up to its present position in the engineering industry in India. They organised the formation and expansion of various associate companies engaged in indigenous manufacture and through their far-sightedness arrangements were made for the training of many Indian engineers with firms overseas, both in the United Kingdom and in America. They have taken no small part in the advancement of industry in India and undoubtedly can take away with them happy memories of many successful achievements during their sojourn in our country.

Transmission of power by Fluid Couplings

The most numerous problems which arise in the transmission of mechanical power are those which concern starting and stopping and transmission at variable or adjustable ratios of speed. Fluid transmission provides answers to these problems in the simplest and most direct way by means of the two basic types of fluid coupling which have been developed by the Fluidrive Engineering Co. Ltd. of Worton Road, Isleworth, Middlesex. These types are known as the Traction Coupling and the Scoop-control Coupling and the Development of both types is associated with the name of Mr. Harold Sinclair, M.I. Mech. E.

The traction coupling, which in its earliest form was known as the 'Fluid Flywheel', is largely employed to permit easy starting and to prevent stalling of internal combustion engines and alternating current electric motors when connected to heavy loads. The drive is taken up smoothly and automatically as the engine or motor is accelerated and at normal speeds of revolutions it is practically positive with an average efficiency of 96 to 98 per cent.

The Scoop-Controlled Coupling is commonly used for speed regulation in connection with constant-speed driving Motor or internal combustion engine, and it is also used for connecting and disconnecting the driven shaft to and from the prime mover.

In common with all couplings for transmitting power from prime mover to driven unit, two revolving elements are involved, one of which (the impeller) is keyed to the shaft extension of the motor or engine and the other (the runner) to the output shaft. There is, however, no mechanical connection between impeller and runner. The two members—driving and driven—are enclosed in an oil tight casing which forms a reservoir for the oil fluid and which is bolted to the impeller. Both impeller and runner have peripheral cavities divided into a series of cells by vanes radiating from the central hub.

Rotation of the impeller causes the oil to flow by centrifugal force to the periphery whence two motions are impared to it—one axial and the other a vortex motion causing transfer of energy from impeller to runner and setting the latter in motion. This motion builds up rapidly until the speed of rotation of the two elements nearly coincides. A final 'slip' of 2 to 3 percent is normal, otherwise no circulation of the oil fluid would take place. The level of the oil in the casing may be varied to suit the torque and acceleration characteristics. The torque transmitted can be limited to a predetermined safe value, even if the drive is suddenly stalled. The fluid coupling thus provides a positive safeguard against stalling the motor by overload, while transmitting the designed overload torque to the driven shaft. As soon as the overload conditions is cleared, the coupling automatically speeds up.

In Scoop-controlled coupling, the prime elements of impeller, runner and working-fluid circuit exist as the traction coupling, but in addition an outer casing forming a fluid reservoir is bolted to a flange on the back of the inner casing so that the impeller, inner casing and outer reservoir revolve together at the speed of the prime mover. The runner is bolted to the output shaft and revolves on ball and roller bearings housed within the inner casing. The Scoop tube and its control element are held in a stationery housing located inside the output end of the outer casing. By varying the position of the scoop tube, the filling and emptying of the working circuit may be effected to any degree whilst running, thus enabling speed variation of the output shaft. Complete connection or disconnection of the drive to or from a continuously running motor can be obtained by filling or emptying the working circuit, this being effected simply by moving the scoop tube to the desired position. The scoop tube may be left in the engaged position when running, so that the working circuit is kept full, and the coupling then has the general characteristics of the traction-type coupling. There is therefore the added advantage that regulation of the scoop tube will give a wide range of speed control, and disconnection when required.

It will be clear from the foregoing that the applications of these couplings are diverse and that fluid couplings have many possible uses in the various industries. A number of traction-type fluid couplings are used all over the world for driving equipment like Conveyors, Crushers, Ball Mills, Pulverisers, Carding Engines, Paddle-type Mixers etc., while scoop-controlled couplings are used for regulating automatically the speeds of induced draught and forced draught fans in power station boilers and also in many other industrial application. A large number of fluid couplings are already working all over India in the thermal power stations at Ahmedabad, Nagpur, Calcutta, Madras, Alwar, Jhansi, Delhi and also many couplings are working in big industrial undertakings like The Tata Iron & Steel Co., Ltd., Indian Iron & Steel Co.,Ltd., etc.

The sole concessionaires in India for these Couplings are Messrs. Greaves Cotton & Co. Ltd., who have their Head Office in Bombay and Branches at Ahmedabad, Calcutta, Coimbatore Delhi, Kanpur and Madras and they have in their staff factory-trained engineers to advise customers on fluidrive problems.

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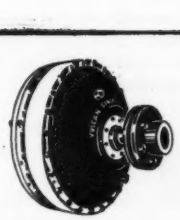
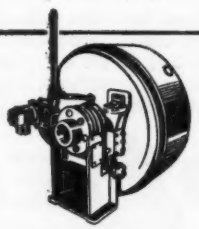
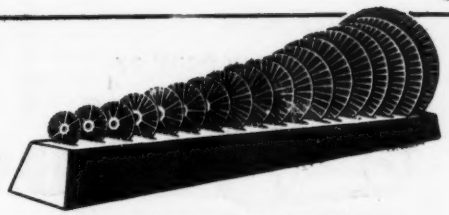


Traction Type Fluid Coupling



Scoop-Control Fluid Coupling



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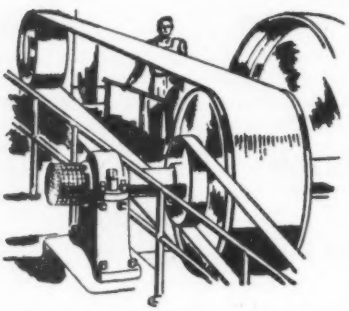

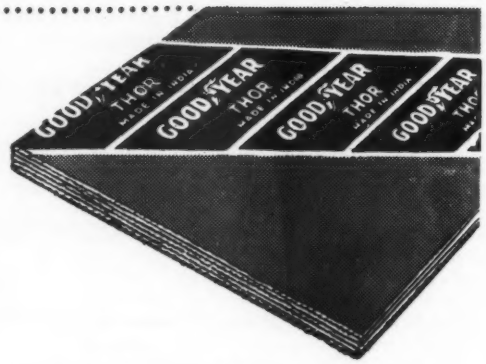

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Second All India Power Engineers' Conference Bangalore, January, 1957

The Second all India Power Engineers' Conference sponsored by the Ministry of Irrigation and Power, Government of India, was held at Bangalore in January 1957. In 1949, that is, eight years earlier, the first Conference was held. Since then the country has made rapid progress both in generation as well as in utilisation. The first Five Year Plan has been completed and the second Plan has already been launched. What could then only be dimly visualised. has already become reality to a large extent and, as the difference in the deliberations of the two Conferences indicate, today we face the practical operational problems and difficulties. 1949 has thus been left far behind and the 1957 conference rightly started with the experience of the first Plan and devoted more time to looking ahead in a more confident manner and to tackle concrete problems of construction.

The Conference was inaugurated by Sri. G. L. Nanda, Minister for Irrigation and Power, Government of India with a speech (published elsewhere in this issue) which set a perspective of power development in India and enumerated the major problems facing the task. From then onwards the delegates consisting of the leading power engineers from all the States, from CW & PC , from Ministers of Communications, Defence, Education, Finance, Heavy Industries, Iron and Steel, Natural Resources and Scientific Research, Production, Railways, Transport, Works, Housing and Supply (CPWD), the Planning Commission, Atomic Energy Department, Irrigation and Power, DVC, Federation of Electricity Undertakings, Indian Institute of Science, Delhi Polytechnic, etc, devoted seven days of discussion of the papers that were circulated in advance.

The papers were classified as under ;

1. Experiences of the First Five Year Plan
2. Electricity Legislation
3. Training of Techmical Personnel
4. Planning for Power Development
5. Load Surveys
6. DC-AC Conversion
7. Power System Design and Operation
8. Rural Electrification
9. Transmission Lines
10. Miscellaneous

The discussion on the Papers were sometimes very intense and occasionally monotonous, as generally happens. But Planning for Power Development, Rural Electrification, Uniform System of Accounting under subject no. 2, provoked keenest attention.

The brief summarises of the Papers under each subject leading are given below :

Experiences of the First Five-Year Plan

1. Problems relating to the slow progress in the First Five Year Plan and suggestions for improvement
   by K. P. Bhat and M. A. Padmanabhaiah.
2. Difficulties experienced in Bihar in procurement and transport of materials during the First Five Year Plan
   by P. R. Sundaram.
3. Experience in the First Five Year Plan
   by C.W. & P.C. (Power Wing).
4. A note on the experiences of the First Five Year Plan in relation to Irrigation & Power Projects
   by P. P. Agarwal, I.C.S.
5. Experience of the First Five Year Plan in relation to Irrigation & Power Projects
   by Chief Engineer for Electricity, Government of Andhra.
6. Experience of the First Five Year Plan in relation to Irrigation & Power Projects
   by S. D. Khungar.
7. Note on the experience of the First Five Year Plan
   by the Electricity Department, Government of Mysore.

In a conference like this, where electrical engineers from all parts of the country are gathered together, it is most appropriate that their experiences during the First Five Year Plan period are discussed for the mutual benefit of all concerned. Among the papers mentioned above, the last four papers had been first submitted for consideration by the Fourth Engineers' Seminar recently held in Hirakud. As discussions during the Seminar were largely centered round the civil engineering aspects of the development schemes, it is felt that these papers could be taken up for consideration in this conference also.

P. R. Sundaram has dealt, in his paper, with the difficulties experienced by the Bihar Government Electricity Department in the matter of procurement of equipment and materials such as transformers, insulators, line supports, conductors etc. He makes a plea for proper and advance appraisal of the requirements of materials for distribution schemes and for advance arrangements for their manufacture. He recommends that there should be an organisational set up in the Central Water & Power Commission for liaison between the indigenous manufacturers and the States so as to assist the latter in the procurement of essential materials without avoidable delay. He also refers to the need for eliminating delays arising from transport bottlenecks.

Bhat and Padmanabhaiah have referred to the importance of regional planning They have pointed

out that power development, especially from resources which are so situated as to be of benefit to more than one State should be conceived on an overall regional basis rather than on the basis of the interests of any particular State. Developing this idea further, they refer to the advantages that would accrue with the Zonal Divisions envisaged by the Government of of India and recommend that in each aone, *River Basin Committees* should be formed who will be in overall charge of the development of power resources in the respective River Valley.

The paper also refers to the necessity of the manufacture within India of heavy electrical machinery and measures to remedy transport bottlenecks and to the training of technical personnel.

The paper contributed by the Power Wing of the CWPC brings out the fact that as a general rule, the growth of load demands on power systems has far exceeded anticipations. This calls for a bold approach in the matter of planning, i.e., power development schemes should be conceived and implemented sufficiently ahead of the actual incidence of load demands. Reference is also made to the delays that have been experienced in the procurement of materials and equipment through the D.G.S. & D. Referring to the import policy of the Government under which it is not ordinarily possible to import equipment manufactured within the country, the inordinate delays that have been experienced in the procurement of various equipment have been explained. In this connection the need for proper co-ordination between the indigenous manufacturing capacity and the requirements by the Electricity Supply Industry has been brought out and certain suggestions which may be discussed in this conferrence have been made to work out a suitable procedure for processing the procurement action.

In his paper, Agarwal has brought out very clearly the several aspects relating to the administration of power development projects. Incidentally the paper brings out clearly that administration is not an "annoying interference" in technical matters but an essential adjunct to the smooth and proper execution of the projects. The paper brings out that the administration should take all the necessary steps to facilitate the smooth progress of the construction works etc. The paper has emphasized the ueed for proper training of the technical personnel, detailed investigations of the projects, the need for a continuing appraisal of loademands, proper co-ordination between the power generation and power utilisation etc. Reference is also made to the possibility of utilising the rural co-operative societies in the promotion of rural electrification schemes. The paper points out that in each project, the authorities should keep a record of difficulties and experiences encountered in the execution thereof, so that such a record would be of assistance and guide in undertaking other projects of similar nature. The paper has brought out several thought-provoking ideas which may be discussed with profit in this Conference.

In connection with very large projects such as Bhakra-Nangal, Khungar has laid stress on the importance of funds being made available as and when required. Uncertainties in the availability of funds would result not only in delays but also in infructuous expenditure on the various parts of the works.

Among other points referred to hy bim are the proper planning and timely supply of raw materials like coal, steel, cement, and the importance of training of technical personnel. The paper also discusses briefly the controversy on the question of machinery versus manual labour. It is pointed out that we should restrict the use of machinery because at the present time we have to import every machine and the spare parts from abroad. However,in certain special situations where time is a vital factor and the work is of such large magnitude that manual labour would be unable to cope up with it, there should be no heistation in adopting the use of machinery. The paper at the same time states that it is of vital importance that manufacture of heavy earth moving and other machinery should be taken up in India as early as possible.

The Chief Engineer for Electricity, Andhra, has broadly referred to questions relating to the training of technical personnel, system of contracts for the construction of distribution lines, standardisation of designs and improvements to remove transport bottlenecks, etc. The paper by the Mysore Electricity Department recounts their experiences on the design and construction of the Jog hydro-electric station.

It will be seen that one of the common problems that has been touched upon in all the papers is in regard to the delays experienced in the procurement of machinery and equipment. In this connection a separate note was circulated to the delegates entitled "A Note on Procurement of Equipment and Material with indigenous angle." The procedure referred to in this note was discussed by the conference and an appropriate resolution indicating the concensus of opinion in this regard formulated and adopted.

Electricity Legislation

1. Public Utility Electric Supply Finance
   by R. P. Aiyer
2. Uniform System of Accounting and Code of Practice as applied to the Electricity Supply Undertaking
   by S. Y. Ramaswamy

The Paper by R. P. Aiyer, deals mostly with difficulties experienced by non-local authority licensees, and the other by S. Y. Ramaswami, deals with the accounting problems generally encountered by the State Electricity Board and to some extent the licensees.

Referring to the Paper "Public Utility Electric Supply Finance," Aiyer has suggested that for the purposes of the Indian Electricity Act, 1910, all State Governments should accept the accounts as audited by the auditors appointed by the licensees under the Indian Companies Act, 1956 without requiring further audit by auditors appointed by the Government.

He has pointed out the vagaries of audit of the accounts of the electricity supply undertakings by auditors appointed by the Government, arising as a a result of the interpretation of the provisions of the Sixth Schedule to the Electricity (Supply) Act, 1948. He has suggested resort to the provision of Clause XVI of the Sixth Schedule to the Electricity (Supply) Act, 1948 by referring the question of interpretation to arbitration by the Central Electricity Authority.

He has referred to a number of disputes between the licensee and the State Government relating to the following provisions of the Electricity (Supply) Act, 1948 :—

(*a*) Admissibility of interest on loan capital as on operating expenditure.

(*b*) Limitation of dividends to 3% until all arrears of depreciation (as distinct from the depreciation for the year in question and instalments in respect of arrears) have been written off.

(*c*) Inclusion in Capital Base of cost of assets no longer in use.

(*d*) Inclusion in Capital Base of intangible assets such as expenditure incurred on issue of new capital.

(*e*) Inclusion in Capital Base of monies expended towards Work-in-progress.

(*f*) Disallowance of donations as expenditure for purposes of rate making.

(*g*) Appropriation to Contingencies Reserve, one Government holding the view that it should be from existing Reserves, the Licensees being of the opinion that it could be either from the revenues of the year or existing Reserves.

Issues referred to at (*a*) (*b*) and (*c*) have already been clarified in the Amending Bill as passed by the Lok and Rajya Sabhas and assented to by the President. The other issues referred to above have also been cleared up by the Central Electricity Authority in their awards.

Aiyer has criticised the working of the Rating Committees inasmuch as he has questioned their competency to interpret the provisions of the Sixth Schedule to the Electricity (Supply) Act, 1948. He has further pointed out the special problem of small undertakings and has suggested that the small-size undertakings should be encouraged and nurtured by discreet application of the provisions of the sixth Schedule, especially as such undertakings have been instrumental in opening up the country-side.

He has suggested that the road to expansion should be free from statutory pin-pricks, so that the undertakings may concentrate on the main task of electrical developments in the sphere allotted to them within the financial codes.

The second Paper deals with the advisablity of uniform system of accounting and preparation of a code of practice. The author suggests that the Boards of all States should prepare and render accounts in uniform statement forms to enable comparative studies. He has recommended that the Code of Practice should provide for uniform system of preparation of accounts as well as the method of their audit.

Training of Technical Personnel

1. Training of Technical personnel by F. C. Kohli
2. Training of Technical Personnel by R. L. Butail

The authors, F. C. Kohil and R. L. Butail, of the two Papers have stressed the importance of training technical personnel on proper and planned lines in the organization itself before their absorption therein. Both have classified technical personnel, employed in the industry, in 3 categories viz., Professional or Cadet Engineer, Technicians or Operating staff, and Artisans or skilled tradesmen.

Kohli has, besides outlining the purpose of an organized training, gives detailed programme for such training. His suggestions are somewhat on the lines of the training methods, adopted by the Tata Hydro-Electric Companies, Bombay. He is of the opinion that on account of the highly complex nature of operations of the electric supply undertakings, proper training is possible only in the undertakings. The author has indicated the expenses involved in establishing organizations for imparting training on sound lines.

In his Paper, Butail has pointed out the shortcomings of technically trained personnel. Considering the rate of increase in the generating capacity envisaged under the Five Year Plans, the author is of the the opinion that there would be a serious gap between supply and demand of trained personnel. His opinion is based on the findings of the University Commission, the Engineering Personnel Committee and the River Valley Projects Technical Personnel Committee appointed by the Government of India. He considers that the gap could be narrowed, if the electric supply undertakings adopt the practices followed in Britain, U.S.A., and Sweden in connection with training of technical personnel. He has suggested the appointment of a committee for the purpose.

The basic problem of training of personnel in Electricity Supply undertakings has been dealt with in both the Papers. It is contended by the authors that proper training, which would materially contribute towards the improvement and efficient performance of technical personnel, is not an easy task and cannot be achieved except with the close co-operation of both the public and private sectors of the electric supply industry. It is, therefore, for consideration as to how the desired results for utilizing the entire available technical talent in the country for the electric supply industry could be achieved and the part that the electric supply industry in particular can play to further this end.

The other important question for consideration of the Conference is as to how quickly the present need of the country in general, and the public electric utilities in particular, in respect of the trained engineering personnel of all the categories, could be met. Further the ways and means to be adopted for bridging the existing gap of the shortage of such personnel in the shortest possible time require considera tion.

Butail has further made the following suggestions viz :—

(*a*) Creation of conditions whereby senior members of the staff of the undertakings take adequate interest in the trainees to enable them to discharge efficiently the duties of the jobs to be entrusted to them.

(*b*) Creation of conditions of service which would result incentive for promoting specialisation such as creation of "All India Service of Power Engineers."

(*c*) Picking up Graduates and Diploma-holders from Institutions for training in undertakings for absorption therein. The author opines that this will not only eliminate frustration of young engineers, which is very common, but will result in marked increase in the availability of engineering personnel for the execution of various projects.

(*d*) Recruitment of the students, with creditable performances in Matriculation, Intermediate and Degrees examinations, for training in the undertakings and certification and their subsequent absorption as technicians and artisans in the undertakings. Butail contends that this method would result in quicker training of technicians and artisans and also work as a large reservoir of potential technical manpower for the industry to draw upon.

(*e*) The Electricity Boards and Project authorities (except small undertakings) to run their own training schools, on the British and the U.S.A models, within their own organisations to train personnel enumerated in (*c*) & (*d*) above.

(*f*) Possibility of imparting administrative training in addition to the technical training, specially to the professional engineers, on the lines followed in the U.S.A. The author feels that if such an arrangement is made possible, it will create a class of administrators who, by virtue of their technical knowledge, will be able to run the administration of large undertakings and projects efficiently;

(*g*) Payment to trainees during there training and the training period taken as a probation for subsequent absorption in the undertakings.

(*h*) Running of refresher courses for the employees for increasing efficiency all round.

Planning for Power Development

1. Regional Plan for Power Development in India
   by K. L. Vij and C. K. Chandran
2. Power Development on Regional Basis
   by T. S. Rao
3. Power Development on Regional Basis
   by M. A. Padmanabhiah
4. Inductive Coordination
   by V. R. Raghavan, N. Venkatesan and T. V. Thadani.
5. Economics of Power Transmission
   by H. R. Kulkarni

Most of the above Papers refer to the need for formulation of power planning on the basis of certain regions. However some of the Papers deal with administration and organisational problems whereas certain others deal with technical aspects.

Vij and Chandran have in their Paper made a detailed analysis of the various factors connected with planned power development in the country and they have attempted to show that there are certain natural concentrations of power resources and that future development of these power ressources should be on the basis of regions having such power concentrations. The Paper makes an examination of the past trends of load growth and attempt to forecast the probable demands in the future. Based on past experience in several foreign countries and in India on the growth of load demands in power systems, the paper forecasts that demand for power in the country will double itself very eight years. The power development programme envisaged in the second Five Year Plan calls for doubling the generating capacity in the country in slightly less than a five-year period.

The forecast of the probable load demand is followed by a study of the characteristics and economics of power resources available in the country both thermal and hydro. Referring to the preliminary hydro-electric power potential surveys on which the C.W.P.C. have been working for the last 3-4 years, the paper draws the following conclusions :—

(*a*) that the bulk of future generation of hydro power will be from *single purpose* hydro-electric schemes, and

(*b*) that the larger sources of hydro power are concentrated together in a small number of compact areas forming concentrations of power.

The process of planning really implies that for achieving the desired objective, all the possible alternatives should be duly considered and the most suitable choice made, from the point of view of ecomonics, speed in achieving results and their repercussions on future developments etc. As far as the power development schemes are concerned, these would mean that we should be fully aware of the available resources of power generation, their location, their magnitude and financial implications. We should also be well-informed about possibilities and location of load development. Developing these ideas, the Paper recommends that future planning for power should be on the basis of regions. There are, according to this Paper, eight natural geographic regions into which India can be divided for purposes of power development. Power generation and power transmission in each of the regions should be properly co-ordinated and developed.

T. S. Rao also has recommended a regional basis for the planning of power development, but he deals chiefly with organisational aspects. He reviews the history of the power supply industry in the recent past in India. Trends of regional power development in several foreign countries such as U.K., Continental countries, Canada, USSR, South America, New Zealand, U.S.A. are briefly mentioned. A detailed account is also given of the growth of power supply in Japan in the post-war years, the organisational set-up of Japanese power supply industry and other connected activities such as electric power survey, electric power research etc.

The Paper subscribes to the view that the basis of regionalisation should be that the various parts of the country should be benefited in equal measure. The author has suggested that the areas covered by the proposed Zonal councils could form regions for power development. He proposes that Regional Electricity Authorities should be constituted for each of the Zones which should be charged with the full responsibility for power development and power supply in the region. A Central Electricity Commission of the status of an independant Government Department has also been proposed for co-ordinating the activities of the Regional Authorities from an overall

national viewpoint. The organisational set up for these Regional and National authorities and the distribution of their functions have been dealt with at length in the Paper.

The impression which this Paper gives is that the proposals involve large number of co-ordinating and advisory organisations and it is a matter for consideration if multiplicity of such bodies assist the rapid development of power supply industry..

Padmanabhaiah has also dealt with organisational problems. He recommends that Technical Councils should be attached to the 5 Zonal Councils which have been formed under the States Reorganisation. These Technical Councils would have in their membership, the representatives of Highways, P.W.D., and Electricity. The idea seems to be that the Zonal Councils should have some kind of technical counterpart, and the planning of power schemes in respective zones should be vested in these councils. The organisation chart recommended does not seem to serve the purposes in view.

Kulkarni points out in his Paper that a good knowledge of the implications and economics of transmitting power from generating sources to the points of utilisation is very essential. While the locations, magnitude and distribution of power resources of this this country and the economics of their development are high-lighted in their Paper by Vij and Chandran, the economics of transmitting power has been dealt with by Kulkarni.

He has worked out curves showing the cost of transmission versus distance in miles. These curves together with the equations worked out in this Paper would enable the evaluation of the cost of energy at the specific load centres, from several alternative sources of power supply. These would help in making a right choice of the very many possible alternatives.

Raghavan, Venkatesan and Thadani have reviewed the progress made in the field of inductive coordination between power and telecommunication lines. As a result of co-operative and joint effort between the Posts & Telegraphs Department and the Electricity Supply Industry, it has been possible to work out in most cases, standard codes of valuating induction in communication circuits and devise remedial measures mutually acceptable to both power and communication interests. It may be recalled that the Central Standing Committee of Co-ordination of Power and Telecommunication Lines was established by the Government of India on the recommendations of the All India Power Engineers Conference held in 1949, and it is a matter of satisfaction that this committee has done commendable work in promoting proper understanding between the telecommunication engineers and the power engineers and in the speedy disposal of a large number of inductive co-ordination cases which were referred to them. The Paper however points out that although the progress has been reasonably satisfactory, much more needs to be done.

Load Surveys

1. Load Survey and its promotion in Andhra State
by B. P. Sastry and
I. Basavaraju

2. Electrical Load Development and Tariff Design
by R. V. Kulkarni and
H. R. Vajifdar

The authors of the first Paper stress the importance of undertaking proper load survey before commencing on a Power Project. The methods of load survey and its organisation in rural and semi-urban areas as adopted on a standardised basis in Andhra, have been described in detail. Propaganda and demonstrations on an intensive scale and personal contacts with potential consumers are recommended.

This Paper further points out that the gap between the availability of power and its utilisation should be reduced to the minimum to ensure quick results in making the investment productive. This could be achieved by advance utilisation of major transmission lines by operating them at lower voltages initially and building up load in the areas concerned by installing pilot or nursery thermal station. To achieve further quicker results, emphasis has been laid on giving free service connections for agricultural and small industrial consumers, formation of Co-operative Societies, introduction of hire purchase system for electrical appliances and providing assistance towards domestic and commercial electrical installations. Servicing of agricultural pumping sets at nominal rates is also recommended. Inspite of adoption of all the promotional measures it has been felt that Rural Electrification Schemes would need initial financial subsidy to become self-supporting.

The extension to a service in Andhra State is considered remunerative, if the capital cost is recouped from sale of energy within 10 years. In case of major projects for generation of power, these are considered remunerative if the net revenue realised at the endof 10 years is not less than 3% on the total capital outlay including arrears of interest.

The second Paper deals with two distinct subjects—conducting electrical load survey and fixation of tariffs for various types of industries. The Paper describes the methods adopted for conducting a load survey in the Bombay Region which includes personal contact with potential consumers to find out their immediate and long-term requirements. It is also recommended to contact local authorities with regard to general development schemes for the area such as waterworks, sewage pumping, etc. Some examples have been worked out to show how to assess requirements of power for domestic, commercial and small industrial consumers.

Under the subject of tariffs, the theories of flat rate and promotional tariffs have been discussed. The basis of fixation of tariffs by the Bombay Electricity Board has been indicated. While on the subject, it has been stressed that a tariff framed "on the basis of approximate cost of giving services to each class of load served, and the consumers' ability to pay" could not be made applicable to rural consumers. It has therefore been stressed that a subsidy in some form or the other is required for electrification in rural areas. One of the ways suggested is to spread large and heavy industries in the rural areas so as to make it possible to extend rural lines therefrom in the surrounding areas.

For promotion and development of electrical load in rural areas, some suggestions have been made to reduce the cost of service lines for agricultural and small industrial consumers.

Some examples of economics of rural supply in various areas of Bombay have been worked out. Uniformity in tariff has been stated to be the ultimate aim of the Bombay Electricity Board.

Points for Discussion :

1. Suggestions to improve methods of Load Investigations.
2. Measures to be taken to build up load in advance in an area before the commissioning of a major power project in order to ensure the least time lag between availability of power from it and its full utilisation.
3. Simplification of the tariff structure specially for rural areas.
4. Formation of Regional Standing Committees for co-ordinated planned development and load promotion of various regions.

DC/AC Conversion

Two papers on the subject were discussed. One was by T. S. Rao and another by R. P. Aiyer.

Technical Considerations

Few will quarrel with the contention that from a purely technical point of view, standardisation of the system of supply is desirable. Also, it will not be denied that the production and distribution of direct current must inevitably raise the overall costs of an undertaking and similarly that the acquisition and maintenance of D.C. plant must also tend to raise cost of production of the consumer.

Legal Considerations

Both Rao and Aiyer have pointed out that the Indian Electricity Act makes no specific provision regarding responsibility for the cost of changing over consumers' apparatus. Aiyer in his Paper has quoted the views of Gangadhariah and Ferro but these, while they do not resolve the legal question, display a somewhat immature comprehension of the economics of electricity supply. Rao points out that the inadequacy of the existing legislation results from the fact that changeover was not contemplated at the time when the existing law was enacted and Aiyer holds that such provisions as do exist, in a lawyer's eyes at least, would seem to give very full protection to the consumer.

Rao has gone very fully into the procedure which he thinks should be adopted in amending the existing legislation and he has made concrete suggestions for the action which State Governments should take, if and when the Central Act is amended in accordance with his recommendations. Briefly, his proposal is is that the Central Act should forbid the supply of D.C. energy after 1.1. 1975 or such earlier date as may be fixed by the State Government in respect of each individual undertaking. While the the Private Sector of the Industry might not resist the former proposal the latter, it is certain, would fill them with the gravest apprehension even if State Governments were prepared to implement the whole of Rao's recommendations.

Rao's next suggestion is that the revised legislation should arm the licensee with the right to refuse to give a D.C. supply for additional loads where he is in a position to offer A.C. This already appears in the "Conditions of Supply" of certain undertakings ; in Calcutta the limit is 50 kW.

Rao's next requirement, with which no licensee would quarrel, is that the consumer should be made responsible for changing over all his apparatus (other than the meter etc.) at his own expense. Rao then makes a spirited attempt to provide a basis for a maximum levy, the financial implications of which will be considered later in this summary. He then suggests a veto on the import of generating plant subject to Central Government permits and he suggests the constitution of a reserve pool of D.C. plant. Many with experience, of bureaucratic methods will view with concern the former suggestion but the latter seems to be a sound idea although a number of local pools would seem to be necessary. Rao's ninth proposal concerns a Central Government directive but this, it must be remembered, would have no legal force at all because *electricity is not a Central but a Concurrent subject* and most State Governments are perhaps rather sensitive on this point.

Rao's further legal proposals take the form of a suggested executive order which might be issued by State Governments after the enactment of his proposed amendment of the 1910 Act. In his proposals to amend the Act, he has suggested that the consumer should be responsible for changing over his own apparatus at his own cost. In this section however, he makes provision for a scale of compensation to apply and these two suggestions therefore appear to be somewhat incompatible.

Aiyer has made no specific provisions for amending the existing legislation, but in general, his attitude is that changeover should take place by "evolution" whereas Rao, it would seem, is an advocate of "revolution."

Economic Considerations

(*a*) *Priority of Capital Expenditure*:

In stating that the proportion of D.C. power generated to the total is very small, Aiyer tends to mask the significance of the conversion figure. The Calcutta Company for instance converts annually nearly 300,000,000 units to D.C.—a formidable total. Aiyer however draws attention to various pronouncements on the cost of changeover made by State Government Electrical Inspectors and others with a view to showing that the cost of any comprehensive scheme would provide an overwhelming stumbling block. Rao, on the other hand, waives this conclusion aside and he is most emphatic that the present is the proper time for the implementation of his proposals. He claims that delay will only aggravate the difficulties which may be true, but the question as to whether capital used on conversion projects would not better be employed in affording new supplies or increasing existing generation and transmission capacity is one which merits the most critical examination of this Conference. The capital available to the Industry both in the public and in the private sector is strictly

limited and the difficulty of raising it will not decrease during the period of the second Five-Year Plan. This is a factor which impresses itself much more forcibly on executives of undertakings run by Private Enterprise than on those operated by the Authorities, and it seems that Rao has based his conclusions without giving due weight to the enormous sums involved in the areas most seriously affected.

(*b*) *Responsibility of Capital Expenditure*

Let us now examine Rao's financial proposals. He suggests that by an executive order, licensees should be empowered to levy a surcharge "not exceeding 6 pies per unit for domestic consumers using lights and fans and 3 pies per unit for heating and motor power loads including domestic appliances driven by small motors." In addition, he suggests that the State Government should refund to the licensee the electricity duty recovered from consumers in D.C. areas. In the case of the Calcutta Company with approximately 180,000 D.C. consumers, the cost of providing A.C. mains etc. would amount to not much less than Rs. 15 crores, a figure comparable with the earlier estimates of the cost of the entire D.V.C. project! In addition, consumers in this single licensed area would be required to replace approximately 1 million D.C. fans which at an average cost of Rs. 175 would total the enormous sum of Rs. 17.5 crores. The cost of changing over existing motors cannot be computed but it would obviously amount to another very large sum. Now assuming that a capital sum of Rs. 15 crores could be made available for conversion, then to service this capital at 5 % would cost Rs. 82.5 lakhs per annum, and to this must be added depreciation which even at a low figure of 2% would amount to Rs. 27 lakhs a year. The total of these two figures would amount to Rs. 109.5 lakhs per annum. The charges of the Calcutta Company are modest so that if a levy of 3 pies was to be made to the heating and small power tariffs, the the surcharge would amount to an increase in most cases of about 26%. This might be supportable, but it would not bring in very much additional revenue. Almost all the burden would have to be borne by the D.C. lighting and fan consumers, the revenue from whom amounts to a little over Rs. 2 crores a year. Rao has suggested a levy of 6 pies per unit in this case but from the foregoing figures it will be evident that this would be insufficient except perhaps in the early years of the project. At a rough guess it can be held that the cost might require a surcharge of As. 1.0 at the lighting and fan rate which at present stands at As. 2.5 nett and As. 3.0 gross. But the Government is already levying a duty of As. 1.0 and in view of the present shortage of State funds and the existing State deficit, it would not be realistic to imagine that Government would forego this bounty. To ask D.C. consumers to bear the additional burden would merely be to court serious civil commotion, a risk which it is certain would not be entertained by the State Government and would certainly not be advocated by the undertaking concerned. It must also be borne in mind that existing depreciation would still have to be collected from consumers in respect of the obsolescent D.C. network until such time as this was written off, although against this, it is true, can be offset about Rs. 45 lakhs for recovered cable. The above figures indicate the magnitude of Rao's proposals in terms of one undertaking alone and this leads us to the question as to whether it would not be possible to concentrate on alleviation rather than elimination of the difficulty.

(*c*) *Alleviation without Consumer or Government Subsidy*

Assuming that the consumer in particular and the public in general cannot be called upon to bear or share the burden of the cost of changeover, the question then arises as to alternatives which if adopted would tend to check the growth of D.C. load and encourage the demand for A.C. supplies. The following are suggested as a basis for discussion in the hope that others will be forthcoming :—

(*i*) Restriction of D.C. demands in the Conditions of Supply with the alternative of a compulsory high voltage supply of alternating current coupled with no compensation.

(*ii*) The selective laying of duplicate L.V. mains in certain areas where free accommodation is afforded for a Substation (if necessary).

(*iii*) Inducement to changeover large individual D.C. buildings at the expense of the consumer by affording a special low rate for high voltage A.C. supplies. This in effect would make such a consumer a wholesaler of energy.

Compensation to Consumers

Rao has given very interesting details of the compensation which his undertaking pays for motor replacements. These terms, it appears, amount to about half the replacement cost of an equivalent A.C. motor. He emphasizes the danger of increasing the rates of compensation which no doubt is very real. The Conference may therefore consider the proposal that where compensation is to be paid, the initial rates of compensation should be stepped-up fairly high and coupled with a statement that these will be reduced progressively by a certain percentage every two years say 25%. The actual percentage could of course be tailored to the speed at which the undertaking could effect the changeover. Naturally, it is desirable that such a proposal should be coupled with a form of levy as visualised in Rao's Paper. It must however be emphasized that this suggestion would not be appropriate in every case.

Power System Design and Operation

The Papers for to-day's discussion are :—

1. Load Despatching in an interconnected Hydro-Thermal System
   by F. C. Kohli
2. Problems of Hydro-Thermal Interconnected Operation
   by S. A. Quader
3. Problems of Design, Construction and Operation of Thermal Stations
   by Madras Electricity Department.
4. Some Considerations relating to Design, Construction and Operation of Thermal Power Stations
   by C. J. Scudamore
5. Suitability of Coal for Power Station Boilers
   by K. C. Gupta
6. Some Problems in Operation of Electrical Utility System
   by M. A. Padmanabhia and S. Krishnamurthy

7. Economics of Power Transformer Selection and Application
by C. S. Sreenivasan
8. Modern Methods of Telecommunication Facilities for Large Power Systems
by Madras Electricity Department

The eight Papers presented under the theme of "Power System Design and Operation" cover a wide field in design, operation and maintenance of Thermal Plants, economic operation of Hydro-Thermal systems, load despatching, fuel problems, economics of transformer selection, carrier communications, and many other related topics. The authors are to be congratulated on writing such interesting and comprehensive Papers.

An interesting feature of these Papers is that many common problems are referred to in more than one Paper, thereby indicating the relative importance of these problems. While it is true that the problems faced in operation by different concerns may differ in detail, yet it is advantageous for operating engineers of one concern to discuss their problems with operating engineers of other concerns as a result of which some alternative avenues may be found. Today's forum offers facility for discussing and showing these experiences. Some of these common problems and also other interesting points covered by these Papers are summarised below for the purpose of discussion.

1. *Operation of Inter-connected Hydro-Thermal Stations*

Quader points out that the interconnection of Hussainsagar thermal station with Nizamsagar hydrostation will result in saving of fuel to the extent of Rs. 11 lakhs per year. The guiding principle in effecting interchanges is overall economy and not economy in any particular station alone.

The Madras Electricity Department have pointed out that after interconnecting Madras Thermal Power Station with hydro stations, the thermal station's load factor jumped from 58 to 82% during the low hydro periods when energy was exported and thereby increasing the efficiency of the plant. During high hydro period, imports from hydro resulted in savings of fuel.

The fundamentals of load forecasting, production allocation, arranging of pre-arranged outages, consideration of line losses, energy inter-change accounting, etc. to achieve optimum efficiency in an interconnected network operation are outlined in Kohli's Paper on Load Despatching. The concepts of incremental heat rate in operating a number of steam generating units and composite efficiency of a number of hydro units as introduced in this Paper establishes a rational basis for loading a number of steam and hydro units in a large interconnected system in order to achieve maximum economy in water rate and fuel rate.

2. *Design and Layout of Thermal Plants*

Scudamore's and Madras Electricity Department's Papers treat comprehensively various factors like selection of site, design of foundations, provision of cooling water and towers, design of building and layout, size and type of boiler and turbine plants, coal and ash handling equipment etc.

In neither of these Papers, unit systems are favoured as the outage of any one element will mean loss of capacity for the whole unit. Whether or not this conclusion can be extended to larger power systems where units of 50 mW or more are to be installed requires further consideration.

The Madras Electricity Department feel that conservation of coal is a vital factor and, therefore, recommend plants of higher thermal efficiency irrespective of capital cost.

On the subject of number and capacity of plant, it is Madras Electricity Department's experience that load forecast for 10 years is realised in six years. It recommends that in an independent station 3 units be installed, each in capacity equal to 10 years load forecast, which would mean that the first unit will be loaded in 6 years, the second by 12th year and the 3rd serve as standby. This arrangement according to Madras Electricity Department will obviate the need for any extension in the station during the next 10 years. This view of Madras Elecrticity Department needs more detailed examination as to whether such a design will be good economics or not.

At Madras Thermal Station, the chemical properties of the make-up cooling water are worse than the sea water. It is treated with copper sulphate to prevent algae growth instead of chlorine which was found to be expensive. It will be interesting to find out the experiences of others on this topic.

3. *Coal* :

Coal supply to power plants is of varying quality and often of unsuitable varieties. Ash content varies upto 30%. Coal with constituents causing bonded deposits and with ash of low melting temperature results in reduced availability and inefficient operation of boiler plant. Scudamore suggests thatc ollieries should supply better quality of coal for power plant operation by screening and treating it before despatch. Gupta recommends that each power plant should receive supply of coal nearest to the quality it is designed for. He feels that there is urgent need for research in classification of coals and determination of the most efficient method of combustion for various classes of coal. The Madras Electricity Department suggest that boiler plant should be specified so as to use any kind of coal as it will never be possible to obtain the desired quality coal, while Scudamore does not consider designing a boiler which will satisfactorily take an assortment of qualities of coal possible.

4. *Operation of Thermal Plants* :

(*a*) *Bunking of Boilers* :

The bunking practices are referred to in Quader's and Madras Electricity Department's Papers. Both the Papers suggest that boilers should not be bunked if it is possible to re-distribute load on the boilers in service without being required to schedule below the mining load limit. The Madras Electricity Deparrtment recommend that if bunking of a boiler is required because of load and economy consideration, it should be bunked at reduced pressure. To avoid superheater tube distortion, Madras Electricity Department recommend keeping superheater drain open during the bunking although it is their experience that this is not necessary if the pressure is lower than 200 lb.

On the topic of starting and bunking losses, Kohli has made an observation that some times, taking these losses into consideration, it would cost less to run the sets during light load periods along with the other machines than to cut it out and restore it to service after a few hours of shutdown, although the running of the set may cause inefficient distribution of load on the other sets in service. Therefore, cutting out of sets and boilers for a few hours to achieve efficient loading on sets in service should be weighed against starting and bunking losses and increased cost of maintenance inherent in bunking of boilers.

(*b*) *Starting and Stopping of Turbines* :

Quader has made useful graphs indicating the minimum time required to bring the turbine to speed or to effect a load change for given temperatures and other conditions.

Padmanabhiah and Krishnamurthi have outlined the procedure and precautions followed in Andhra for starting and stopping of turbines. The Madras Electricity Department recommend that the load should be picked up at a rate not higher that 1 mW per minute.

5. *Standardisation of Plant Specifications* :

The Madras Electricity Department feel that it will be useful to have some sort of standard specifications drawn up for Thermal plants for guidance of all public and private undertakings, so that when specifications have to be issued by an undertaking, only the salient features of the plant requirement of the particular station need be added and specifications issued out.

They also feel that it is preferable to have one main contractor for all the main work of plant and machinery.

6. *Training of Personnel* :

Scudamore points out that it is difficult to obtain experienced and qualified operators. He, therefore, suggests that each large station should train as many operators as possible with a view to supply not only its own requirements but those of the country in general. The Madras Electricity Department suggest that contractors should operate the plant from 3 to 6 months with their own people, and during this period they should train power station people suitably on operation and maintenance. It is also desirable to depute personnel intended to operate and maintain the new plant for training with the contractors during erection for a period of at least 3 months prior to the commissioning of the plant.

7. *Economics of power transformer selection and application* :

Sreenivasan discusses the operating characteristics and economics of various design features of transformers. He points out that proper evaluations of factors like single three-phase unit or three single-phase units, type of cooling, type of connection, number of windings, impedance, insulation level etc. may result into sizeable economies.

8. *Carrier Communications* :

It is interesting to note the reasons that prompted Madras Electricity Department to go in for carrier communications. The reasons are that communications over overhead telephone wires fail just at the time they are most needed and also large scale thefts of copper conductor often occur. These problems, perhaps, are faced by most of the utility concerns covering a large territory. The system of "wave-change" in carrier communication needs to be discussed in further detail as power engineers associated with communication problems may not be entirely familiar with it.

9. *Multipurpose Projects* :

Quader recommends close cooperation between the irrigation and power engineers to make the combined operation most effective for both purposes. He also suggests that while designing an irrigation project some consideration should be given to the possibility of utilising the project for power generation at a later date as without this thought at design stage, it would be difficult to adopt civil structures designed purely for irrigation purpose for power generation purpose.

Rural Electrification

The Papers for discussion were :—

1. Use of Aluminium Conductors in Rural Distribution and H.T. Distributors
   by S. Sanka an and P. N. Raman
2. Rural Electrification
   by A. R. K. Murthy
3. Rural Electrification, Standardization of Designs
   by S. Sukhatirtha and K. S. Raman
4. Services to Consumer Premises in Rural Areas
   by S. Sankaran and P. N. Raman
5. Some Notes on Policy for Future Rural Electrification
   by M. Datta
6. Rural Electrification
   by Madras Electricity Department
7. Rural Electrification
   by A. P. Seethapathy
8. Cheaper Construction of Rural Lines and their Standardisation
   by P. T. Seshan

In the Papers that have been presented, stress has been laid by a number of writers on the urgent need for standardization of designs and construction practices pertaining to Rural Electrification. Although, with the present scarcity of materials, standardisation may be difficult for adoption to the full extent, yet its necessity is inescapable if we have to achieve economy. Standards need to be evolved at least on a zonal basis depending on the materials available.

Separate standards for urban and rural areas have been recommended by a number of authors. Although the revised I.E. Rules help considerably in reducing the cost of the feeder and distribution lines, yet there are suggestions to liberalise still further the standards and make them applicable only to the rural areas in order to cut down the cost of the rural distribution lines to the barest minimum. Relaxation of the I.E. Rules with regard to the provision of guards, danger

boards, anti-climbing device and other miscellaneous items have been suggested by Seshan and Seethapathy.

The use of all-aluminium conductors for the rural areas has been recommended by S. Sankaran & P. N. Raman. It has been explained that there need not be any misgivings about the use of all-aluminium conductors in view of the improvements achieved in the technique of the design and manufacture of the fittings. In view of the availability of vast resources of bauxite in India and the rapidly dwindling stock of copper in the world, the use of aluminium would, out of necessity alone, assume great importance.

Utilization of wood poles for the rural lines to the maximum extent has been suggested by P. T. Seshan to cut down the cost. It has been indicated that there is not enough co-ordination between the Forest and the Electricity Departments of the States, resulting in restricting the availability of the poles from indigenous sources. It has been further added that the use of jointed wood poles and lowering of the factors of safety may enable the Forest Department to supply more poles for the distribution network than at present.

A. P. Seethapathy and Datta have made several suggestions to include prospective consumers to take power supply and to encourage load development. These relate to waiving of service connection charges or increasing the free limit for service connections, giving loans for purchase of materials for internal wiring and equipment, offering equipment and materials on hire-purchase system, lowering of the security deposits, waiving of the minimum guarantees etc.

Staggering of the agricultural loads in the rural parts to bring down the maximum demand and create better load factor on the system with its apparent advantages has been advocated by A. R. K. Murthy. Suggestions have also been made to adopt single-phase distribution while the Madras Electricity Department have sounded a note of caution with regard to change-over to single-phase distribution as it does not afford any substantial relief in costs and suffers from the disadvantage of not being able to meet the three phase pattern of load likely to develop in due course.

In the Paper contributed by the Madras Electricity Department, the economics of rural electrification is discussed in detail and the need for some sort of subsidy is emphasized. This subsidy may be in the form of (*i*) an outright grant to meet the capital either in full or in part or (*ii*) an interest-free loan to meet the capital either in full or in part or (*iii*) an annual subsidy to meet the shortfall of revenue required to cover the working expenses including interest.

Transmission Lines

The Papers for discussion were :—

1. Stringing of A.C.S.R. Conductors
   by D. N. Halbe and
   M. F. Choonawala
2. Practical Problems Relating to Surveys, Foundations and Erection of H. V. Transmission Line
   by G. T. Sathe
3. Resume of Design Factors Favouring Omission of Continuous Earth Wire on Overhead Sub-Transmission Lines (11-33 kV)
   by V. Venugopalan and
   K. R. S. Iyengar
4. Wind Pressures for Transmission Line Designs
   by G. V. Karve
5. Fault Locating Equipment on Transmission Lines
   by S. S. Murthy
6. Thunderstorm Data and Lightning Protection of Transmission Lines
   by V. Venugopalan and
   S. S. Murthy

Paper No. 1 :
This Paper briefly describes a method of stringing conductors on transmission lines which the authors call "the loop messenger method."

This method has so far been tried on a very limited scale. Its economics vis-a-vis the conventional method should be studied critically for various conditions of terrain, different types of transmission lines, etc., and if results are encouraging, it could be universally adopted. Even if the economy of cost is not significant, any saving of stringing time alone is likely to be a sufficient incentive for its adoption, considering that climatic factors and agricultural activities often severely restrict the effective working season in many parts of the country.

Simultaneously, the feasibility of more widespread use of power winches for pulling of conductors should be investigated.

Papwe No. 2 :
This Paper touches upon some of the fundamental practical problems relating to construction of high voltage transmission lines.

Small angle towers can be adopted to advantage in coal fields and thickly populated or industrial areas.

While the author envisages straight runs at times, even for 4 to 6 miles, some power utilities seldom achieve straight runs beyond 2/3 miles ; longer stretches of straight runs should preferably be sectionalised, each stringing section being confined to about 3 miles, to facilitate construction and maintenance, particularly for lines strung with heavy conductors.

Aerial surveys and photographs of proposed line routes with helicopters owned by groups of power utilities for routine aerial patrolling of lines in operation is a distinct possibility in the future which will ensure overall economy and swiftness of line construction.

Early streamlining of the procedure for obtaining approval of the railway authorities to proposed crossings, as suggested by the author, needs immediate attention of the C.W. & P.C., who should also assist the Railway Board in evolving country-wide standards for transmission line crossings commensurate with economy and safety.

Many power utilities in the country are at present constructing specially large spans of transmission lines

for river and valley crossings, data on which should be collected with a view to publishing a comprehensive volume on the subject illustrating various features applicable to unique local problems.

Transmission line engineers will be greatly benefited if the C.W. & P.C. can move the State Governments to codify precise practical procedures of payment of compensation for trees and crops and to establish scheduled rates of compensation applicable to transmission lines where the associated land (right of way) is not acquired.

The author has illustrated typical foundations. Results of his studies on angle of repose for different kinds of soil will be interesting. Also, a discussion on the minimum depth of foundation required for effectively engaging the frustum of a pyramid will be profitable to many.

It will be interesting to know if the author has tried steel grillage, square or triangular, against values of uplift higher than 1,50,000 lbs, or raft type foundation for tower base wider than 15 feet or so and with excessive effective ground pressure. Lateral resistance of earth at depths more than 3 to 4 feet is a factor worth consideration according to some authorities.

Paper No. 3 :

The authors have discussed in this article salient design features of overhead sub-transmission lines (11/33 kV) carried on metal and wooden supports with all-wood as well as metal cross arms and have justified the omission of continuous earthwire.

Their suggestion to utilise the wood impulse insulation of all-wood supports has ample scope for widespread adoption in this country. Earlier attempts at popularising wooden supports for H.T. Lines have had severe set-backs owing to wood preservating technique not having been developed and enforced in the country simultaneously. Once this difficulty is overcome, perhaps, all-wood construction where climatic and other factors permit its adoption, will not be halting.

For low cost protection against lightning, possibility of indigenous manufacture of protector tubes should also be explored. Simultaneously, country-wide collation of statistical data on performance of various existing transmission lines should be initiated immediately. The long experience of the Electricity Department of Mysore and Kashmir on the performance of wood pole sub-transmission lines should be utilised.

Paper No. 4 :

In this article the author advocates the adoption of 25 lbs. and 12 lbs. of wind pressure per sq. ft. for two zones into whichh e recommends the country to be divided.

The experience of various power utilities as regards the capacity of their existing lines to withstand the rigours of heavy gales particularly in the coastal regions notorious for devastating storms, should be carefully studied before adopting the author's suggestion in preference to the Code of Practice published by the C.W. & P.C. in September, 1952. No doubt, if the lower pressure chart is found safe for adoption, there will be considerable economy in line costs.

Paper No. 5 :

This Paper describes briefly two types of equipment, viz., the Transient Fault Detector and the Sustained Fault Detector.

The Transient Fault Detector, which is not normally required in a power system, is capable of giving very accurate measurement whenever faults are cleared simultaneously from both ends, as is the case with modern carrier current relays. It will be interesting to know whether this instrument gives satisfactory results if product type or directional over-current type relays are employed for earth fault protection, in which case, the fault will be cleared by sequential tripping of circuit breakers.

The Sustained Fault Detectors need not be very accurate, as an error of 1 to 2 miles in locating the fault can be tolerated.

It will be worthwhile to compare the performance of fault locating equipment manufactured in other countries with the French and Australian equipment described by the author.

Paper No. 6 :

This Paper stresses the necessity of collecting reliable data on lightning.

Discussions were invited for developing the proforma adopted by the C.W. & P.C. for collation of lightning data.

A few well-equipped weather stations can be established for the purpose.

D.V.C. area being subjected to severe lightning storm, as indicated in the isoceraunic map, may be selected for intensive study of the lightning phonomena vis-a-vis, its effects on the performance of H.T. transmission lines.

Miscellaneous

The papers for discussion were :—

1. Power Supply in Trains
   by S. L. Narayana Iyer
2. Economics of Storage Air Conditioning
   by K. G. Bell and
   U. Ritter
5. Standardisation of Designs and Construction of River Valley Projects
   by M. C. Sampath Iengar
6. Need for Specification of Impulse Testing on Transformers below 2,000 kVA, 35 kV, with reference to conditions in India
   by P. R. Sundaram and
   B. Chaudhari

Paper No. 1 :

The author, after tracing the history of power supply in trains on the Indian Railways, has stated that consequent on the increase in loading, a stage has been reached on metre gauge system when the existing double battery parallel block system cannot meet the requirements satisfactorily, particularly in slow trains having long halts. He has discussed three alternative proposals, namely :

(1) Attaching a separate generating car,
(2) Supplying the power requirements from a turbo-generator mounted on the engine, and

(3) Having diesel engine sets mounted on brake vans to supply the whole energy requirements.

He has recommended the installation of small diesel sets generating at 110. A.C. in brake vans as an economical and efficient solution to the problem.

It is suggested that the following points be discussed :

The relative technical and economic merits of the existing double battery parallel block system, self-contained generating single battery equipment for each coach and "end-on" generation with diesel generating units mounted in brake vans, with particular reference to :

(*i*) The flexibility of operation so that any coach can be attached to or detached from any rake and coupled to any block rake system of supply.
(*ii*) Continuity of supply during shunting operations when the train will have to be parted in two, to insert or pull out slip coaches or when coaches have to be stationed on sidings for long hours with lights and fans on, for the benefit of passengers.
(*iii*) Use of coaching stock fed from "end-on" generating units with 110 volts D.C. or A.C. supply when mixed with existing 24 volts system.

Paper No. 2 :
The authors have discussed thoroughly the economics of air conditioning of factories and offices in large buildings with three types of air-conditioning plants, as follows :

(*i*) Standard chilled water plant termed "Day-Load" plant usually operated between 8-30A.M. and 5-30 P.M. only.
(*ii*) Storage air conditioning plant termed "Load Factor" Plant operating throughout or most of the 24 hours employing chilled water storage tank and smaller size of compressor.
(*iii*) Storage air conditioning plant termed 'Off-peak' plant employing compressor plant of the same size as the Day Load plant but with larger storage tank and operated during the off-peak periods between 8 P.M. to 5-30 A.M. and 11-15 A.M. to 12-45 P.M.

The comparative capital and operating costs, excluding repairs and maintenance, of hypothetical plants of the above three types operating under similar conditions and with the load factor and off-peak tariffs as proposed by them, have been worked out in the Paper.

The authors have brought out clearly the technical and economic advantages accruing both to the supply authority and the consumer taking high tension supply, in the adoption of storage air-conditioning in preference to the orthodox 'Day-Load' air conditioning plant. They have recommended that such a system should be encouraged and licensees would be justified in insisting on local legislation to prevent consumers deploying generating capacity for operating large air conditioning plants.

The following points are suggested for discussion :

(*i*) Technical and economic merits of the three types of plant from the point of view of supply authority,
(*ii*) The economic rates to be offerred to encourage the installation of storage air conditioning plant and the conditions under which the supply authority would be justified in offering very low rates to induce the consumer to operate the plant during off-peak load period only.
(*iii*) The necessity and justification for insisting on local legislation to prevent consumers operating large air-conditioning plants during peak load periods of the supply suthority.

Paper 5 :
The author in his Paper indicates the various anomalies and defects existing in the planning, designing and execution of River Valley Projects, and has raised, among others, the following points which are suggested for discussion :

(*i*) Planning of River Valley Projects should be done valley-wise and not State-wise, and standardisation is desirable on a zonal or All-India basis. The Central Water & Power Commission should be a planning and advisory body entrusted with the task of drawing up plans for all River Valleys in India.
(*ii*) The design, investigation and preparation of projects should be done on a standardised basis by State Governments, who must maintain a design organisation exclusively for this purpose, and a standard form of estimate in regard to requirements of men and materials for the projects should be evolved on an all-India or zonal basis.
(*iii*) The Survey and Construction Department should be provided with standardised amenities, such as rent-free quarters, free medical aid and, free lighting, travelling expenses and extra employments in order to employ the best talent available, and the number and type of buildings to be provided by the State Government should be clearly defined for large and small projects on an All-India or zonal basis.
(*iv*) To avoid delay in the execution of works, the Chief Engineer of the project should also be the Secretary to the Government, and empowered with wide powers of sanction, recruitment, etc., and the staff of other departments, such as the Police, Medical, Health, Revenue, Forests, etc. should be placed under the administrative control of the Engineering Department engaged on the construction of the project.
(*v*) The Accounts and Audit Department should take full responsibility for a few of the works accounts and a decision should be taken on the suitability of the pre-audit or post-audit system in order to ensure rapid execution of the works.

Finally, it may be useful to discuss the Author's suggestion on the need for the appointment of a high power committee of engineers of various States and one Accounts Officer to go into the above questions thoroughly and recommend ways and means for effecting standardisation and economy in the planning, design and execution of the various River Valley Projects.

Continued on page 32

Editorial Notes

Early this year we had some important engineering events, namely, the opening of the Hirakud Dam and Power House, the Engineers' Seminar and the Second All India Power Engineers' Conference. Coming one after the other in the same month, it made a great impact. The Seminar has become a regular periodic feature and has contributed greatly to the evolution of general all-India policies and outlook on broad engineering and administrative problems with respect to river valley and power projects. The Power Conference, also convened by the Central Ministry for Irrigation and Power, concentrated on problems relating to the development of electricity and its utilisation. The first such conference was held in 1949 and another was really overdue. The tasks of electricity engineers have become clearer with the fulfilment of the First National Plan and the formulation of the second. Immediately after independence one could faintly guess the dynamics and magnitude of economic development of the country. Now one could perceive a general layout and the rate of growth. The resolutions, therefore, have been very timely and realistic. For the moment we would like to draw special attention to the urgent need for regional planning. Too much emphasis on the State boundaries and provincial exclusivism and self-sufficiency, as is the trend prevalent today, is not conducive to efficiency and integral development. It is therefore, not merely a technical problem but also a problem of outlook.

* * *

This journal took the initiative in organising a symposium on Power & Water Resource Development in West Bengal under the auspices of the Indian Science Congress during its session in Calcutta. Dr. B. C. Roy, the General President of the Congress, inaugurated it. Papers were received from many scholars of various departments of the Government of India and of West Bengal. The fields of meteorology, geology, forestry, soil conservation, hydrology, electricity, fuel research geography, agriculture etc. were amply represented during its sessions and there was vigorous discussion. The papers together with notes on discussion will soon be published and this will add to the growing literature on resource development in India. We are sure that other States would like to have such symposia and we are taking steps that these be organised. We are confident that engineers and others will be eager to participate.

* * *

The Centenary of the Bengal Engineering College at Sibpore was held in a fitting manner. The two great events of the occasion that will be long cherished were the very interesting Exhibition and the Symposium sponsored by the organisers. In this connection one should not fail to remember the centenary celebrations of the Universities of Calcutta, Madras and Bombay. It is in this way that the foundations of modern outlook and life were laid a hundred years before, of which we are not only the fruits but also the beneficiaries. In those early days there was vigorous resistance from the o thodox and the traditionalists to the introduction of English education and to foreign travel. We should pay our homage to all these, Indians and foreigners, who took courage in both hands and vigorously went ahead in securely laying the edifice of modern education.

* * *

News of an Australian scientist discovering a method of reducing the loss from evaporation of water is indeed very encouraging. The process consists of using an insoluble chemical, hexadecanol, in the form of beads about $\frac{1}{8}$th of an inch in diamater to discharge a protective film. On the earthen tank or dam which holds his water supply, the farmer launches a special raft containing hexadecanol beads inside a gauze basket. One lb. of beads in needed for each raft.

* * *

From the beads, the invisible film spreads across the whole dam within minutes. Resistant to wind and dust, this film restricts evaporation. Should it accidentally be broken, the beads supply additional hexadecanol to heal the break. So far this method has been found to be effective only in such small areas of water as 2 acres. Further research is proceeding so that this may be possible over larger stretches of water. Of course it was known for many years that hexadecanol would be the stuff which can combat evaporation but the form and the proportion was in question. In view of the importance of the subject for India with numerous small tanks and large reservoirs, it may be useful that our researchers take up the subject afresh and find out not only how the process could be effective over large areas of water but also how economically this process can be applied by our farmers.

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Second All India Power Engineers' Conference, Bangalore, January, 1957

Paper 6 :

The authors have, in their Paper, stressed the need for impulse testing of transformers below 2,000 kVA and for voltages of 33 kV and below. They have stated that no standard system of impulse testing is in vogue in this country and that the State Governments have different policies in regard to the fixing of impulse levels and specification of impulse tests for transformers. They have further discussed the methods for detection of failures of transformers during and after impulse test and the desirability to collect accumulated data in India on this subject.

The following points are suggested for discussion :

(*i*) The kVA and voltage ratings of transformers for which impulse testing may be dispensed with.

(*ii*) The adoption of insulation levels and impulse voltage tests for Power transformers as per the recommendations of BEAMA until revised B. S. 171 is issued.

(*iii*) Collation of necessary data regarding insoceraunic levels and ascertaining the degree of severity and number of surges faced by transformers by the provision of surge counters fitted to the Lightning Arresters protecting the transformers.

(*iv*) The need for further study and research on the subject with a view to simplifying the interpretation of test results and rationalisation of the impulse testing specification.

The Conference adopted several resolutions. These will be published in the next issue of the journal. We greatefully acknowledge the help and cooperation of the Ministry of Irrigation and Power in the preparation of this report.

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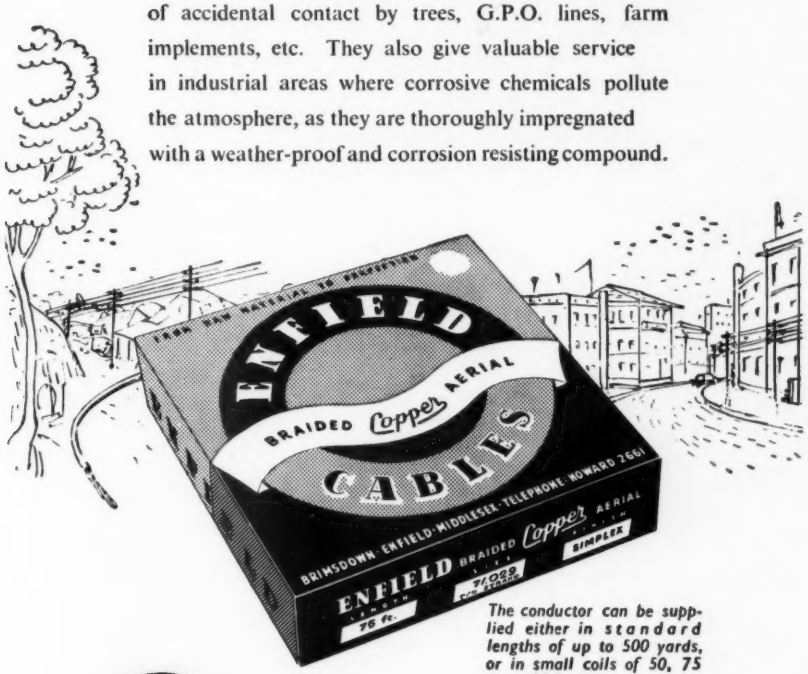

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